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Graphic design + biomimicry

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GRAPHIC DESIGN + BIOMIMICRY

Integrating Nature into Modern Design Practices

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Contents

Abstract

GRAPHIC DESIGN + BIOMIMICRY: Integrating Nature into Modern Design Practices is a thesis that explores how to effectively integrate the methodologies and principles of graphic design and biomimicry. The objective is to create an innovative design process resulting in successful, sustainable and timeless design solutions. This process is meant to remind designers of the benefits nature has to offer in helping us solve many of the problems that society is currently grappling with today. Nature over 3.8 billion years has already used its imaginative prowess to find what works, what is appropriate, and most importantly, what lasts here on Earth.

The final print application acts as a resource guidebook cataloging all of the research, processes, and findings throughout the documentation of this thesis. This includes the indirect method; applying nature's fourteen design principles with the fourteen universal design principles and elements, as well as the direct method of the biomimetic design process; applying the six stages: (1) Defining, (2) Analyzing, (3) Observing, (4) Selecting, (5) Implementing, and (6) Evaluating. Each chapter within the resource guidebook is defined by each stage in the graphic design + biomimicry process. Informational charts, diagrams, text and photographs are also included throughout to enhance user comprehension of the subject matter that is presented.

Overall, this thesis is meant to encourage designers to think differently, forcing themselves to innovate, experiment, push and adapt their designs further than ever before. The objective at hand is to create good design that also has the potential to *do* good, for the world and everything that encompasses it. We are on the cusp of great change: will designers curl up at the thought of this or embrace this new mode of thinking and biomimetic mindset to help shape a positive future for design, people, and most importantly, our planet?

Thesis Blog: http://margaretmckosky.tumblr.com/

Keywords

Graphic Design, Biomimicry, Process, Theory, Nature, Design

Section 1

Section 1 : 1.0 Introduction

This thesis proposes a new biomimetic + graphic design process that is meant to challenge the current paradigms and create the potential for change. Designers will be encouraged by this different way of thinking, forcing themselves to innovate, experiment, push and adapt their designs further than ever before. The objective at hand is to create good design that also has the potential to *do* good, for the world and everything that encompasses it.

Naturally, as designers we are problem solvers. We apply our creative talents to finding new and appropriately innovative solutions to common questions. These questions may include how to best articulate a brand, how to connect with a particular audience or how to communicate across cultural boundaries. Now more than ever there are bigger problems than just brands and connecting to consumers. There are fundamental needs such as equality, education, food, water, community, and sustainability. As graphic designers we should be creating work that has a purpose. There is a lot of beautiful graphic design work being done everyday, but what is it for?

This thesis is also about trying to find work that has meaning and that will ultimately make a positive impact. I understand there is very necessary work designers must do every day that may not have the most meaning to them or influenced by nature's designs. I am not saying that biomimetic graphic design and *good* design should be held above that of design which seeks to do anything less than help save the world. Good design in this context is defined as being made using life's principles, eco-friendly materials, optimizes all materials rather maximizing, involves cross-disciplinary teamwork, etc. Any inference that the work presented within this thesis and final print application or *good* design that applies life's principles or uses eco-friendly materials is more noble or worthy is not my intention. The purpose of this thesis is to raise awareness, propose a new mindset and celebrate this newfound biomimetic graphic design process. Whether for the greater good or greater profit, it is all still why we do what we do.

That said, it is very easy for graphic designers to get caught up in only pleasing clients, focusing on articulating their message in order to communicate with their audience. Sometimes designers become too focused on one aspect and forget about how their piece will fit in with the rest of the 'ecosystem' and the other functions a piece should serve. Since we work in a cultural business, we have the potential to change our client's perceptions of their consumption patterns as well as our own, helping to reduce our overall carbon footprint. This perhaps is the greatest leverage point for biomimetic-graphic design. We must learn to be a part of a multi-disciplinary brainstorming team in order to identify the best leverage points for the most change.

After engaging in this thesis and guidebook, designers will know how to do this, using the biomimetic principles to help guide them. I am hoping designers will try to incorporate this new design process and take away a new mode of thinking; applying this process not just into their work, but into all aspects of their lives allowing them to be more creative overall.

In the final print application of this thesis I have tried embracing what others have done before me, exhibiting what they have found and proposing my own ideas and solutions. It is the accumulation of all my research and should act as a catalog of my ideas and findings. Hopefully after looking and reading through this reference guidebook, designers will be encouraged by this graphic design + biomimicry process.

1.1 Thesis Statement

What Would Nature Do? Integrating Biomimicry + Graphic Design to Effectively Create an Innovative Design Process

1.2 Problem Statement

Will this new and innovative design process of integrating biomimicry with graphic design help designers to think differently, using nature as their inspiration in order create more sustainable design solutions?

1.3 Situation Analysis

Biomimicry is a relatively new discipline that studies nature's finest ideas and then attempts to imitate these designs and processes to solve human problems. It is simply innovation inspired by nature, or as Janine Benyus, one of the leading researchers of biomimicry today, would say it is the 'conscious emulation of life's genius on the path to a sustainable future.' The core concept is that nature over 3.8 billion years has already used its imaginative prowess to solve many of the problems that society is currently grappling with today. Nature has found what works, what is appropriate, and most importantly what lasts here on Earth.

That said, life found within nature is the secret to survival and the area to which we should be seeking the answers to our problems. In order to emulate nature's genius and reflect it onto our existing world, we must view nature in an entirely different manner.

As the Biomimicry Guild and Institute believes, we need to look at nature as model, measure, and mentor. The Guild and its collaborators have developed a specific practical design tool called the Biomimicry Design Spiral based on the Golden Ratio for using nature as model which helps to further explain this notion.

Sustainability is also an important contributing factor and recurring theme throughout the process of biomimicry. Essentially, it is the goal when using biomimicry within the realm of design to create hybrids of timeless, sustainable pieces. This is where nature as measure is introduced. In learning from the principal factors that work within nature, we can then embed them into our own sustainable design solutions.

Lastly, in viewing nature as mentor, it is a summation of how one should view nature with a modern outlook. It is vital to note that biomimicry introduces an era based not on what we can extract from nature and all that it encompasses but on what we can potentially take away and learn from nature. When the worlds of biomimicry and graphic design mesh, a beautiful landscape of opportunities will emerge.

The challenge at hand is to take these time-tested ideals nature has produced over the years and echo them to produce effective design solutions. By constituting nature as model, measure and as mentor, a new way of evaluating and creating effective design solutions will emerge out of the abyss of the already creative design process to an entirely new, innovative process full of potential.

Biomimicry can be used as a tool to create more sustainable design solutions because it is a design methodology itself, occurring in the ideation phase of the graphic design process rather than the execution phase. For instance, a designer would start with a human design problem, identifying the root of challenge and then review how nature would go about solving this problem. *What would nature do?* It is crucial to look at the natural form, process, and system already found within nature so one can mimic its process within the ideation stage.

There will be a cross-fertilization of ideas along the way, but in the end, the juggernaut of biomimicry will shed a new light onto the field of graphic design. Thus creating an avant-garde mode of thinking which in turn will lead to an alternate, innovative and revolutionary graphic design process.

1.4 Target Audience

The specific target audience for this thesis is designers at the collegiate and professional level who are knowledgeable and trained within the field of design. However, people who are interested in graphic design and/or biomimicry, yet are unaware of the methodologies of either disciplines, will be able to understand the concepts presented within the book.

Demographics

Age: 18 and higher

Gender: Male or Female

Education: Collegiate and Professional level

Interest

Design

Science

Biomimicry

Reading

Learning

Section 2

Section 2 : 2.0 Research

In addition to understanding the methodology and process of graphic design, this thesis requires an extensive background, knowledge and degree of understanding of the field of biomimicry. In order to understand the methodology of biomimicry and become more knowledgeable in the subject matter, an in-depth survey and review of literature was done. To create a new process based on the methodologies of both biomimicry and graphic design, it was critical that the principles and elements that combine to make up each discipline were also researched thoroughly. This thesis uses these principles and elements found within nature and graphic design to ultimately form the proposed graphic design + biomimicry process.

In order to know how this thesis combined with design and nature can positively impact modern design practices, it was also necessary to research how modern design practices are functioning within the industry today. The innovators and pioneers of biomimicry who are making the field prominent within today's design industry were extremely important when investigating this aspect of the thesis project. The sole person responsible for this recently emerging field of biomimicry is Janine Benyus, author of the book *Biomimicry: Innovation Inspired by Nature,* as well as the founder of The Biomimicry Guild (1996), The Biomimicry Institute (2005), AskNature.org (2007), and Biomimicry 3.8 (2010). Biomimicry has become more widespread within the industry now than ever before because of Benyus and innovators like her. In order to truly know how biomimicry should be integrated within the graphic design process, it was key to interview and converse with designers at the Institute who work with the biomimetic approach everyday. A phone conference was arranged to ensure that all of the proper principles and factors that contribute to the biomimetic design process were met and introduced within my own proposed process.

Since this thesis revolves heavily around theory and process, it was very important to also research the biomimetic system, diagrams and approaches that the designers at the Biomimicry Institute use everyday within their own creative process. A comprehensive analysis was done after speaking with designers at the Institute in order to compare and contrast their process with my own. It is integral to note that the biomimetic mindset and attitude are equally as important as the final proposed process and were researched just as extensively.

2.1 Survey of Literature

Biomimicry

Nature's Operating Instructions: The True Biotechnologies

Ausubel, Kenny. *Nature's Operating Instructions: The True Biotechnologies*. Sierra Club Books, 2004.

This book is divided into five parts. Part I opens a window onto biomimicry and the myriad of imaginative technological applications drawn from nature that have shown the capacity to decontaminate our polluted world. Part II looks directly at the ways of the land and how people are using those to help the land heal itself. Part III provides a cautionary glimpse into the basic conceptual flaws embedded in the design of current so-called biotechnologies and illustrates some of the consequent threats to the environment. Part IV applies nature's operating instructions to industry's central production processes and touches on some of the thorny political and economic factors blocking their wider acceptance. Part V searches the human heart and spirit to invoke our unique cultural facility to create an earth-honoring civilization. This book further relays the notion that biomimicry is innovation inspired by nature, looking to nature as a teacher and mentor. I will use this resource in helping my research of the biomimetic process within design.

Biomimicry: Innovation Inspired by Nature

Benyus, Janine M. *Biomimicry: Innovation Inspired by Nature*. New York: William Morrow and Company, Inc., 1997.

"Why Biomimicry Now? Biomimicry is a new science that studies nature's models and then imitates or takes inspiration from these designs and processes to solve human problems, e.g., a solar cell inspired by a leaf." Janine Benyus does a superb job in providing a thorough explanation of the biomimetic world and all that it encompasses. The book itself is told in her own narrative where she dispenses case studies that she either witnessed or was actually a part of. Within the case studies she presents how we can learn from nature today, using nature's perfect sense of design that has been successful for billions of years as a solution model for the most basic human problems. Benyus describes biomimicry in a variety of areas and environments which are concisely laid out from chapter to chapter. For instance, she examines biomimicry in the way we feed ourselves, how we harness energy, how we heal ourselves, how we conduct business and so on. What I have surveyed in this book is specifically how biomimicry can inspire and innovate how we make things fitting form to function; e.g., weaving fibers like a spider. Benyus bestows a lot of useful information regarding biomimicry within design and I will use this book extensively throughout my research.

The Way Nature Works
Rees, Robin. *The Way Nature Works*. Mitchell Beazley International Ltd., 1992.

This book specifically targets the way the earth and its living organisms function providing scientific answers to questions that arise when looking at the world around us. It encompasses the earth and its atmosphere through evolution and on to the extraordinary diversity of form and behavior seen among today's living species. This resource will be especially helpful in looking and researching how organisms function in their natural environments and how nature's good design over the years has lead to survival for all living species among their habitats.

Design Lessons from Nature
Taylor, Benjamin De Brie. *Design Lessons from Nature.* New York: Watson-Guptill Publications, 1974.

This source is unique in the fact that it contains the substance of talks that were given to a freshman class at Pratt Institute in the 1967 - 1968 academic year. It contains photographs of the work done by the students in the class. The course was established in an attempt to display the relationships that exist between nature and art and to propose problems which "would represent a logical sequence in the development of drawing skills as well as in the understanding of design problems." Although this book is dated it still serves as a valuable source in examining nature as art form and the relationship that exists between the two.

Structural Biomaterials
Vincent, Julian. *Structural Biomaterials*. New York: Princeton University Press, 1990.

This book is very scientific and engineering based going deep into the chemistry, biology, and physics that make up the structure of various biomaterials seen in nature. The only section of this book that is of particular interest is in the sixth chapter where the function and design of bone in organisms is discussed. This will help me to understand the scientific process behind the creation of nature's best designs.

Cats' Paws and Catapults: Mechanical Worlds of Nature & People
Vogel, Steven. *Cats Paws and Catapults: Mechanical Worlds of Nature & People.* W.W. Norton & Company, Inc., 1998.

This book looks at the subject area of biomechanics— the technology of life, at the mechanical view of nature. It poses some very good questions and modes of thought such as why should nature do what she does in the best possible way and why does nature provide a model for what we want to do? Vogel wants "to ruffle our tendency to view nature as the gold standard for design and as a great source of technological breakthroughs." This source will be extremely helpful in looking at the cross fertilization of technology, design, and nature.

Biologic: Designing with Nature to Protect the Environment
Wann, David. *Biologic: Designing with Nature to Protect the Environment.* Boulder: Johnson Printing Company, 1994.

Wann does an excellent job in explaining the need for society to rethink the way it views nature, desiring for a 'redesign of culture' where nature is appreciated rather than devalued. This book will primarily be used in the methodology process and how Wann perceives how nature can be used in design to help promote sustainability and provide solutions to some of human's most basic problems.

Deep Design: Pathways to a Liveable Future
Wann, David. Deep Design: Pathways to a Liveable Future. Island Press, 1996.

"We live in a designed world. Everything from where we live, to how we get to work, to what we eat is the result of an endless series of decisions by countless individuals. But rarely is thought given to whole processes or attention paid to how systems should work together. As a result, much of the design in our world is flawed, and with each new technological advance we find ourselves faced with yet another unintended consequence." Wann explores a new way of thinking about design and what the ultimate goal of design should be. The design process should begin with a question and be sensitive to living systems without the side effects of pollution, erosion, congestion, and stress. Sustainability is a key factor in designing for the environment and Wann states how he believes we can achieve the best case scenario of diversity, conservation, and care-taking in the future.

Design

Graphic Design Theory: Readings from the Field
Armstrong, Helen & Lupton, Ellen. *Graphic Design Theory: Readings from the Field.* New York: Princeton Architectural Press, 2009.

As Ellen Lupton states in the foreword, "This book is an introduction to graphic design theory. Each selection, written in its own time and place across a century of design evolution, explores the aesthetic and social purposes of design practice....Theory is all about the question "why?" The process of becoming a designer is focused largely on how: how to use software, how to solve problems, how to organize information, how to get clients, how to work with printers, and so on." This book will be very effective in the theory and design ideation of my application as well as the methodological process. In observing actual case studies, it will be helpful to see solutions other designers came up with and the process they went about to solve the problem they were given, since as designers it is our role to be problem solvers as well.

Geometry of Design: Studies in Proportion and Composition
Elam, Kimberly. *Geometry of Design: Studies in Proportion and Composition*. New York: Princeton Architectural Press, 2001.

Elam stresses that "too often designers see conceptual ideas suffer during the process of realization and ideation in large part because the designer did not understand the visual principles of geometric composition. These principles include an understanding of classic proportioning systems such as the golden selection and root rectangles, as well as ratios and proportion, interrelationships of form, and regulating lines." This book not only goes into detail of natural geometric form seen within organisms but it goes even further to show a wide selection of professional posters, products, and buildings that are visually analyzed by these principles nature herself devised. This source will be helpful in my process in comparing existing structures that are based on natural form and how these forms are not only more aesthetically pleasing but sustainable as well.

Design Writing Research: Writing on Graphic Design
Lupton, Ellen & Miller, J. Abbott. *Design Writing Research: Writing on Graphic Design*. New York: Kiosk, 1996.

Lupton and Miller deconstruct writing on graphic design into three separate categories: theory, media, and history. Their aims and process are neatly summarized in the three noun manifesto— Design/Writing/Research. They use design itself as a tool of explication and analysis and Miller even "suggests a greater than usual density of connections in the wiring of verbal and visual meaning." This will be helpful when writing my own theory on integrating biomimicry within the existing field of graphic design.

Skin: Surface Substance + Design
Lupton, Ellen. *Skin: Surface Substance + Design*. New York: Princeton Architectural Press, 2002.

"Surging fears and ambitions fuel scientific discovery and stimulate the creation and consumption of new technologies. Design reflects and shapes our understanding of the world; it is both symptom and cure. As a practice embedded in the fabric of technology and commerce, design responds critically to the very culture it serves to replicate and extend." In comparing human skin as the largest encompassing organ of humans to materials used throughout design, Lupton shows how design is a complete reflection of how we view the world. Design becomes a signal of intention, meant to convey the meaning of something. This will be used in the research phase of looking at how various materials can be applied to natural forms and processes.

Mixing Messages: Graphic Design in Contemporary Culture
Lupton, Ellen. Mixing Messages: Graphic Design in Contemporary Culture. New York: Princeton Architectural Press, 1996.

"Graphic Design as a process involves the making of visual statements and their use and revision by clients, audiences, and other designers. Mixing characterizes the social life of graphic design. Visual communications elicit divergent responses in a crowded landscape of competing messages. The meaning of signs and styles shifts with the context in which they are sent and received." Throughout this book, Lupton raises the issues and concerns with looking at visual symbols within the culture they are presented and how their perceptions change over time due to the shifting identity seen in contemporary culture. This will be useful in the development of my application since I will have to be aware and concerned with how people will perceive my approach to this new hybrid biomimetic design process. I need to make sure that the messages I am sending through visual communication are understood and can be spread to the masses.

Cradle to Cradle: Remaking the Way We Make Things
McDonough, William & Braungart, Michael. Cradle to Cradle: Remaking the Way We Make Things. New York: North Point Press, 2002.

This book represents "one step toward a radically different approach to designing and producing the objects we use and enjoy, an emerging movement we see as the next industrial revolution. This revolution is founded on nature's surprisingly effective design principles, on human creativity and prosperity, and on respect, fair play, and goodwill. It has the power to transform both industry and environmentalism, as we know them." Cradle to Cradle is a revolutionary book in which McDonough and Braungart wish to raise awareness regarding sustainability and hold ourselves responsible to the negative stigma we have laid upon the earth in regards to pollution, global warming, and so on. "Human industry has been in full swing for little over a century, yet is has brought about a decline in almost every ecosystem on the planet. Nature doesn't have a design problem. People do." This is exactly what I want to illustrate and prove in my thesis and show how in using a different approach and design process, designers can turn our ecological footprint in the right direction. To design products and systems that celebrate the abundance of human creativity, culture, and productivity that are so intelligent and safe our species can leave an ecological footprint to delight in, not lament in.

2.2 Biomimicry

2.2.1 Methodology

"If I could reveal something that was hidden…I would reveal that we live in a confident universe, that we are part of a brilliant planet and that we are surrounded by genius. Biomimicry is a new discipline that tries to learn from those geniuses and take advice, design advice, from them...What's happening now in Biomimicry is people are beginning to remember that the natural world is doing things now that we need to do and doing them gracefully to live here on the planet...What we need to do is to find a way to minimize the amount of materials we use, the kind of materials we use, and add design to it...How can we live here gracefully over the long haul? How can we do what life has learned to do?...which is to create conditions conducive to life...The design challenge of our century is we need a way to remind ourselves of those geniuses and to somehow meet them again."

Janine Benyus

TED Talks: Biomimicry in action, Filmed July 2009

(http://www.ted.com/talks/janine_benyus_biomimicry_in_action.html)

Life's design brief is simple. Learn how to create and make things while creating conditions conducive to life on earth. Since biomimicry has emerged as an ever-evolving discipline, it has proven that life and nature has a lot to teach within the realm of technology and design. The methodology and biomimetic approach is taking the design principles and genius of the natural world and looking at its solutions in order to solve current design challenges. It is simply going out into nature to see her solution to the problem. When it comes to people's understanding of biomimicry, there is not a lack of information, but a lack of integration. What is necessary today in order for designers to create and practice with greater holistic awareness and sustainability is an integration and meshing of both methodologies. Nature has had over 3.8 billion years to research and develop well-adapted solutions including 10 – 30 million different species. Organisms have already solved the problems that designers, engineers, and architects have spent years working on. The answers are everywhere and in order for designers, engineers and architects to see these answers, what is needed is a change in the lens with which they are seeing and observing. The significant aspect to note is that these solutions are solved in context; that context is the earth…the same context with which we are trying to solve design problems. The question designers should ask themselves is how does life make things without using harsh chemicals and manufacturing products via factory lines? How does life make 'things' disappear into systems? The answer is simple. Life creates conditions conducive to life. It builds soil, it cleans air and water, mixes the cocktail of gases that every organism needs to live all while doing it in the middle of great foreplay, and meeting every species' needs. Organisms have figured out a way to do the amazing things they do while taking care of the place that is going to take care of their offspring.

A prime example of an organism that has been doing this is the hummingbird, an organism about the size of a human thumb. It flies up to 35 miles an hour (faster than people can get around most cities in a cab) and migrates about 2,000 miles a year. Those journeying down the eastern flyway reach the tip of the Gulf of Mexico and then pause for a period of time, fueling up on 1,000 blossoms a day. Finally, they burst across 600 miles of open water without stopping, on a whopping 2.1 grams of fuel. And that is not jet fuel: it is nectar. But here is what is amazing. In the process of fueling up, the hummingbird manages to pollinate its energy source, ensuring that there will be nectar next year— for itself, for its offspring, or for completely unrelated species of nectar feeders. Imagine doing that at a gas station. And of course, when it dies, its body decays and nurtures the roots not only of flowers, but of mushrooms, grasses, trees, and shrubs. There is nothing special about it; no government regulations are behind it. It is simply part of the system that keeps us alive.

To better fit in with the rest of nature, humans (graphic designers) can more correctly identify the problem, filter through nature's solutions, think in a systematic perspective, and design for human user experience. Exploring how to integrate biomimicry + graphic design is one of the many avenues to a more sustainable world and is arguably one of the most powerful leverage points to creating conditions conducive to life.

Biomimicry is the conscious emulation of nature's genius— innovation inspired by nature. In a society accustomed to dominating or 'improving' nature, this respectful imitation is a radically new approach; a revolution really. Unlike the Industrial Revolution, the Biomimicry Revolution introduces an era based not on what we can extract from nature, but on what we can learn from her. Biomimicry's methodology is analyzing nature and mimicking its functions and deep patterns to create life-friendly solutions. It is not the aesthetic mimicry of something without function, a point especially important for aspiring biomimetic graphic designers. For example, biomimicry is not converting your canvas size to be the same proportion as the golden ratio because this ratio in nature serves as a streamlining function for growth and water flow. Biomimicry is not die-cutting your piece into the shape of a nautilus shell or simply using color palettes found in nature. This is a common misconception among designers who are just learning and being introduced to biomimetic graphic design. The golden ratio or color palettes found within in nature are a good place to start and use for inspiration, but then one must take these and adapt them in a way that nature would within its ecosystem, providing not only form but function as well. This is where the methodologies of both graphic design and biomimicry intertwine, using some of the basic elements and principles found within design and nature.

Mimicking form, function or shape is just the first step of becoming better adapted. Learning from nature really means remembering nature's processes and ecosystem strategies, that everything is created and done in context for a particular reason in conditions that are conducive to life. Until we understand this and create designs and products that mimic living systems and processes rather than a machine, we have not reached the full potential of biomimicry.

Biomimicry also recognizes the many simple rules and principles obeyed by nature for survival over the long-haul. It's important to understand that biomimicry is iterative and is not immune to the many challenges and time-constraints of working in old systems and paradigms. Therefore, a design that just mimics a few of life's principles or one deep pattern in nature is okay. The design can become more sustainable the second time around. Designers must take notice of this. Biomimicry is an ever-evolving process, always adapting to the current environmental and social conditions. Since design is iterative, there is assurance knowing there is always an opportunity to go back to a project and make it better.

Much of the research in biomimicry is years and years from fruition, yet it is a path; an approach. It requires designers to visit the outdoors and keep asking: How does nature teach? How does nature learn? How does nature heal? How does nature communicate? As humans, we may learn faster but nature has been at it longer. So quieting human cleverness and getting over this fact is the first step in biomimicry. Next, comes listening, then trying to echo what we hear. This emulating is hard and humbling work. When what we learn improves how we live, we grow grateful and that leads to the last step in the path: stewardship and caretaking, a practical thanksgiving for what we have learned (Kenny Ausubel, Nature's Operating Instructions).

Another critical aspect of the methodology of biomimicry is that it requires community, not just with other organisms, but with people in other disciplines. What is needed is to bring together fields of study and to inform corporations of how to utilize cross-disciplinary design tables. As it stands now, biologists are educated to learn how life lives, how life has managed to find out what works and what lasts here on earth. Engineers are trained to find out how we should feed ourselves, power ourselves, make our materials, and run our businesses. Engineers design human systems. So there are the biologists and the engineers, and, very sadly, few people get to work in the fertile crescent between those two intellectual habitats. Yet the rest of nature revels in these in-between places. In fact, abrupt boundaries are rare in nature, and some of the most fertile habitats are commingled edges— like estuaries, where freshwater and salt water come together. What biomimetic designers have been on a quest to find are people who are living in that fertile commingling place, the estuary between biology and human systems design (Kenny Ausubel, Nature's Operating Instructions).

2.2.2 Industry Standards: The Biomimicry Institute

As previously mentioned, Janine Benyus is also the visionary co-founder of Biomimicry 3.8, which was formed by integrating The Biomimicry Institute and The Biomimicry Guild in 2010. Biomimicry 3.8 brings together scientists, engineers, architects, designers and other innovators to create sustainable technologies and business practices. The Biomimicry Institute is also known for creating the ground-breaking database called *AskNature.org,* containing nature's answers to many complex design challenges. The organization achieves this through a global network of experts providing education, professional training, research, analysis and consultation to individuals, institutions and corporations. It is vital to note that the Institute is a not-for-profit organization that promotes the study and imitation of nature's remarkably efficient designs to use those models to create sustainable technologies. Today, Biomimicry 3.8 also offers short-term workshops and a two-year certificate program in biomimicry for professionals. Biomimicry 3.8 focuses on three areas: (1) Developing educational programs for students, professionals and the general public, (2) Working to create public policies that use biomimicry as a solution to sustainability challenges, and (3) Encouraging companies that are profiting from biomimicry to provide financial support for biodiversity. Thanks to the efforts and work of the biologists, designers and innovators at Biomimicry 3.8, more and more designers are realizing a simple truth when trying to find responsible, ecological solutions: If we are trying to do it, chances are, nature already did it better.

Biomimicry is quickly becoming a cornerstone for sustainable design practices and the Institute and Guild have worked with companies to help them achieve ground-breaking designs, products, and materials all inspired by nature. Designers from all over the globe, designing everything from toothbrushes to trains and airplanes, are working to integrate the principles of biomimicry and sustainability into all aspects of design. This includes education, to practice and production, and ultimately consumption. What is happening here within the creative industry is that new standards are being set, ultimately challenging the current paradigms that exist in modern design. Designers are starting to catalyze this new system and way of thinking by collectively building their intelligence around important issues such as climate change and social justice, and tackling those issues and challenges with optimism and creativity. This is the satisfaction a designer is able to attain when modeling his/her work using the biomimetic + graphic design principles. They come up with ideas that they may have never thought of before that nature brilliantly thought of and designed millions of years ago. These ideas can suddenly turn into the most remarkable, yet simplest ideas. In taking these older ideals devised by nature and applying them within a new process, it creates designs that are timeless, innovative, and revolutionary.

However, it is not as simple as it may seem at first. Many designers who want to incorporate biomimicry into their work and design process may not know where to start. Some famous biomimetic solutions have gotten passed around the mainstream press— including examples like self-cleaning surfaces modeled on lotus flowers, or the sticky repositionable tape inspired by gecko feet or wind turbines inspired by whale fins— but biomimicry is not as easy as using nature as a crib sheet.

"One of the big realizations that designers have when they play with biomimicry is that it's not a tool, it's a mindset shift," says Dayna Baumeister, who co-founded the Biomimicry Guild with Benyus in 1998. "Because of that— because of the fundamentally different way of thinking— it's hard." "Even for biologists, it requires a shift in thinking," says Baumeister, "from learning about nature to learning from nature, including how each of those processes fit within a larger ecosystem." "In a way, it's examining nature's solutions for survival, but through a design lens," says Chris Allen, project manager for *AskNature.org*. "You can look at brilliant engineering and strategies living for over thousands of years."

Because biomimicry experts believe that designers play an integral role in making sustainable, nature-inspired decisions in a project, they believe that is where their influence is best appropriated. A biologist working in biomimetic design is known as a Biologist at the Design Table, or, in a biomimetic-appropriate acronym: a BaDT. BaDTs create a bridge to biological understanding. Biomimetic work is deeply rooted in solid science, but it is a BaDT's job to translate that science so designers can immediately make the link to the design challenge. This way biologists are able to be part of the design team from brainstorm to prototype, continually adding biological insight to the process. There are currently very few BaDT's— only about 75 worldwide— since they have to undergo extensive training. But eventually, the goal is to have a BaDT in every design firm who can help guide the designers towards smarter, more nature-influenced solutions.

It is crucial that designers embrace this new set of biomimetic standards and understand that the cross-disciplinary dialogue is a vital and necessary component within the design process in order to emulate designs found within nature. Designers need to continue to collaborate with other professionals. Not strictly biologists, however, but also scientists, engineers, architects...The more areas of expertise in the room, the greater the range of possibilities in coming up with timeless, sustainable design solutions. This new process also gives designers and professionals the competitive edge within the industry. People are extremely invested and interested in the field of biomimicry because it has produced some of the most successful and innovative designs seen today. When products are designed with the biomimetic industry standards, not only are they aesthetically pleasing, they are also modern, functional, sustainable, cost-effective and life-friendly designs.

As previously mentioned, the Guild has worked with world-class companies to help them achieve this shift in thinking, from a long-standing relationship with the flooring and finishes company Interface, to a team currently on-site at an architectural project in India. In India, they are creating buildings that not only are made from natural materials, they actually behave like natural organisms. Using biomimetic principles, we have also been able to learn more about our own species. The Guild is starting conversations with global companies that manufacture goods such as cosmetics— in which case their own in-house scientists have been studying hair and skin for decades. Currently there is a great deal of excitement bridging algorithms found in nature and information technology or 'generative design,' where we are able to extrapolate data from the way that nature goes through its iterative design process in evolution.

It is important to note that to adopt this biomimetic mindset shift, one is also agreeing to adopt responsible design practices. Practicing responsible design is more than just using life-friendly materials and sustainable technologies. It is about raising awareness, getting involved and staying active. It is crucial to let others know about the exciting field of biomimicry and the current biomimetic standards. The easiest way to do this is to adopt these new standards within one's own process and to one's designs. It is also about being active within one's local community and getting involved with any programs or organizations that are striving to create a positive environmental impact. This is the only way to challenge the current paradigms and spread the word about biomimetic design.

Another way one can practice responsible design is to always be conscious of one's surroundings within one's local community and the larger ecosystem we reside in. Use materials that are found locally rather than 'outsourcing' to the internet. Always ask: *What Would Nature Do?* How would nature solve this design problem? If one looks hard enough, what will be found is that nature is where all of the answers to our design problems lie. Good, responsible design practice involves multiple viewpoints and is adaptive to new information.

2.2.3 Innovators at the Institute

Janine Benyus has been devoting her life and career to biomimicry, studying its methodologies and principles over a long period of time. She is the pioneer responsible for the breakthroughs in the field of biomimicry. Her work has been a catalyst for many innovations that emulate nature's processes and has been used in the research, design and manufacturing of many products. She is currently the president of the Biomimicry Institute as well as a biologist at the design table, innovation consultant, and author of six books including *Biomimicry: Innovation Inspired by Nature.*

Benyus began her career in 1996 co-founding the Helena, Montana based Biomimicry Guild with Dr. Dayna Baumeister. Then, in 2005 she co-founded The Biomimicry Institute with Bryony Schwan and in 2007 Chris Allen joined the team to help launch the ground-breaking database *AskNature.org,* the world's first digital library of nature's solutions containing nature's answers to many complex design challenges. Her in-house biologists at the Guild have provided consulting services in design, manufacturing and management to hundreds of corporations, universities, architectural firms and NPO's, including GE, HOK, Boeing, Herman Miller, Interface, Kohler, Kraft, Nike, IDEO and Procter & Gamble. She has also helped to introduce tens of thousands of people to the exciting field of biomimicry through international presentations such as TED talks and GreenBuild. In 2008, Benyus received "Time Magazine's" Heroes of the Environment award and in 2011, she was a recipient of a prestigious Heinz award in the sum of $100,000. Teresa Heinz, chairman of the Heinz Family Foundation, described her as "showing us that the solutions to many of our biggest challenges are right there in front of us in nature's vast reservoir of ideas." While biomimicry has existed as a tool in fields such as chemistry for years, as a methodology it had not crossed over into other disciplines until Benyus took the first stride in doing so.

2.2.4 Phone Conference with Designers

Wednesday February 1, 2012 @ 2pm
Designers: Jessica Jones and Andrea Leggitt

How do you integrate biomimicry within your design process?

- Constantly influenced by life's principles (non-biologists and designers run into the same issues)
- Continuous pattern and process within design, optimize rather than maximize materials
- The Biomimicry Design spiral…don't use it every time since it will not solve *every* design problem. There is so much to design, we know these principles well and how we can make our designs multi-functional, always remembering to use materials after so there is no waste; it is inherently green design overlapping with other frame works and disciplines

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How did you both start incorporating biomimicry and design?

- (Jessica) I learned to take art and nature, turned to nature-based tourism after school, communicating to nature and people through park settings
- Passion for sustainability, respect for life, and art and designing with biomimicry
- Started a blog: designmomentum.wordpress.com
- Design more sustainable in every iteration, building momentum…can't make it in the first go around, time constraints always having to come back to a project and make it better….full list of biomimicry, lots to do and keep in mind and how you think and the whole paradigm shift… not just about incorporating or mimicking a single organism, taking inspiration from nature

- Graphic design and biomimicry is deeper than mimicking design and shapes
- You need to know how to communicate better to people and respect and recycle, look for patterns and how to portray those designs...How does nature communicate?
- There is a Biology into Design Diagram where we acknowledge that all disciplines have different processes…creating, scoping, evaluating
- Bringing biology into the different stages of design, you can start with inspiration in nature or design challenge and then start anywhere in the scope in creating design and biology and then begin the stages of evaluating and scoping and developing…

Are there any examples of case studies you could tell me about of how you specifically incorporated graphic design and biomimicry?

- Celery Design Collaborative: create die-cut tabs while not wasting materials and cross-collaborating, remembering to think of the life's principles along the way
- There is this idea of how creative roles and companies are at a disadvantage by not incorporating biomimicry; a good brainstorming session begins with asking questions and how graphic designers can influence other people (non-designers) within the corporation

- EcoFont: can we influence the typographer coming up with that if we would have been a bit more system thinking and creative …not just how to put a 2D 'thing' on a page
- What happens next?! We develop something and then tell companies how this is just a viable a solution
- If you gave nature a piece of construction paper and asked it to make a leaf, it would cut it into pieces and them reassemble the pieces from the bottom up…but humans would take it, take scissors and cut the shape out of it (original story told by Janine Benyus)

- Interface: makes carpet tiles, designed a carpet tile…this one design is 40% of their sales, success of one carpet tile…cause and effect, whole ethos of company changed– 0 emissions by 2020…bringing in biomimicry in a single project and influencing the entire company
- Inspired by surface graphics…square to mimic how things stick..inspired by the random leaves fall in such a random pattern, why not let something be random?

- Certificate Casing: knowing the products and materials available to you in your environment… scales of graphic designers…like in every discipline, working on a smaller scale, use local resources and building store and they ordered in this bamboo unvarnished wood, good materials to make it..clip isn't the most sustainable yet but always room for improvement, didn't fit completely flat; there is a whole story to advertise
- Every case study is different, just asking questions…really tried to look into something… Ask questions! What would nature do? How, what, where, when?
- (Jessica) "**I give you permission to use any case study examples from my blog in your thesis"**

Where did you work/what did you do before coming to work at the Institute?

- (Andrea) I am an industrial designer by trade, worked for an office/design company... on the human scale (built by a green company, yet all of their sustainable designs are accidental and the attitude didn't match what was being marketed)
- It was frustrating since they only cared about what makes money
- I had an "ah ha!" moment when discovered biomimicry within design and now couldn't be happier with what I do and where I work
- As a designer wasn't able to be expressive and was more of a Sketch-Up monkey, bottom designer
- I really want to educate more people about biomimicry from the get-go

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What is one aspect of biomimicry + graphic design that you think novice designers should be aware of when they are first starting out researching the two methodologies?

- Integrating biomimicry just doesn't have to be done in the visual design stages, its the whole process such as I wish I would have gotten feedback as to how many students are still framing the biomimicry certificate cases we designed, it is our path of a non-profit, easy fix….clipboard case studies, make a case for putting more thought into it.. Make certificates for students who were graduating from their certificate program, get something in paper...or is it about the student getting recognition on a website, or can they pass it on to another student…so many things and doors and avenues and questions and the end purpose and if it is still in fashion to do that…
- Bio-inspiration vs. Biomimicry is important because there is a difference biomimicry- 3 components (ethos, reconnect- designers start learning about it and incorporating biology start seeing nature in a different way, emulate- of models) trying to think of what is the real function of those visuals to sustain life
- Visuals, how does it pertain…cultivating relationships..printers (big) if you come to them to design your business card, made relationship to stock company for them to give you the advantage to their photo database, if you use them they provide you their photos…if you actively pick out a principle, common sense, people aren't doing them they aren't actively seeking it out, relationship, business practices, communicate with people to get things done,
- Strategies to get things done…getting people to know what biomimicry is and to understand that biomimicry isn't just sharp-shaped submarines…majority has been educating people thus far…
- Look at it as a cultural mind-set…can we use these patterns so they look a little more organic or get worn, start out being worn and then be re-used …design function
- Cultural thing that they've done, been ingrained that perfection is beautiful, if it design a design flaw…vintage is beautiful, chipped away but if you got a couch with a corner chipped off it's a flaw
- Team bonding in a fun way thinking about nature…how do we get people to implement these strategies we share…matter of time, get some ideas quick change or higher up strategies… how do biologists at the design table inspire their clients to keep innovating…solution right away might be sad but case studies provide another value…people will reconnect

2.2.5 Life's Principles

The following Life's Principles set in motion by the Institute were used as inspiration in the creation of the 14 Design Principles of Nature devised for this thesis project.

Life's Principles

Operating Conditions

- Water-based World
- Dynamic Non-Equilibrium
- Subject to Limits and Boundaries

Life Creates Conditions Conducive to Life

- Optimize rather than Maximize
- Using multi-functional design
- Fitting form to function

Leveraging Interdependence

- Recycling all materials
- Fostering cooperative relationships
- Self-organizing

Using...

- Benign Manufacturing
- Life-friendly materials
- Water-based chemistry
- Self-assembly

Life Adapts and evolves

- Locally Attuned and Responsive
- Resourceful and opportunistic
- Shape rather than material (Cellular and nested)
- Simple, common building blocks
- Free energy

Feedback Loops

- Antenna, signal, and response
- Learns and imitates

Integrates Cyclic Processes

- Feedback loops
- Cross-pollination and mutation

Resilient

- Diverse
- Decentralized and distributed
- Redundant

2.2.6 14 Design Principles of Nature

Meme, by definition, means an element of a culture or system of behavior that may be considered to be passed from one individual to another by non-genetic means, esp. imitation. Biomimetic graphic design in itself is somewhat of a 'meme.' It is a design process and style that has been spread and passed along throughout today's culture and society via various channels and networks of communication. To be active within this biomimetic graphic design unit, designers must transmit their ideas through the form of cultural analogues that can respond and adapt to the ever-changing times and conditions. To better understand this, it is critical that designers learn, memorize and apply the following design lessons and life principles nature has so graciously given us.

This is the indirect method of beginning to apply the two methodologies; biomimicry + graphic design, by using abstracted principles of how nature designs. These principles of nature are present in all organisms at multiple scales and levels that fuel and inspire deep sustainability. They are the criteria for thriving and surviving on earth, while creating conditions conducive to life and can be applied to all stages of the graphic design or visual communication process. Each principle challenges humans to think systemically within a broader context than just thinking of a single organism. The following principles are a distilled combination of those life's principles enumerated by the Biomimicry Institute and Janine Benyus, Michael Braungart and William McDonough (*Cradle to Cradle*), Steven Vogel (*Cats' Paws and Catapults*), D' Arcy Thompson (*On Growth and Form*), Julian Vincent (*Structural Biomaterials*), Jeremy Faludi (sustainable design strategist and researcher, articles for Worldchanging.com) and my own limited experience of knowledge and research on the subject of biomimetic design.

1 **Self-Assembly from the Ground Up**

The most important things happen at the smallest scales. For instance, on the material level, instead of taking a block of something that you cut away, take small parts that combine to form the whole. This reduces waste and increases design flexibility.

Jessica Jones, the graphic designer and visual communicator at the Institute put it very eloquently when I spoke with her via phone conference...

> If you gave nature a piece of construction paper and asked it to make a leaf, it would cut it into pieces and then reassemble the pieces from the bottom up...but humans would take it, take scissors and cut the shape out of it. (story original told by Janine Benyus)

On the system level, design networks, not pyramids. The nodes should create the overall structure by their interrelations, because this method is more robust, scalable, and flexible than a system with an over-arching plan that must have certain nodes in certain places.

The second aspect of this, 'the most important things happen at the smallest scales,' refers to the fact that the most complex, detail-filled aspects of biological designs are done at the smallest scales: at first, a bone looks like a stick; look closer, and you see its porous structure; look closer, and you see the material is a composite; look closer, and you find that composite has three or four deeper levels of substructure; look closely enough and you get to the DNA, which is complex enough to contain the blueprints for the whole bone and the rest of the animal. Sometimes designing for the most minute detail can cause the whole over-arching design to be determined.

2 **Waste = Food**

This perhaps is one of the most important principles, using waste as a resource rather than disposing of it off in a landfill. Michael Braungart and William McDonough, authors of *Cradle to Cradle: Remaking the Way We Make Things,* have the best developed model for this, with their concept of biological nutrients and technical nutrients. Strictly speaking, as Janine Benyus points out, modern industry does act like ecosystems in nature— a 'type 1' system, the weeds that colonize an area after a disturbance. However, type 1 ecosystems are not sustainable, they eventually give way to type 2 and type 3 ecosystems, which have increasingly greater interdependencies, with increasingly closed-loop resource flows, such as rainforests. Creating type 3 industrial ecosystems has historically been tricky to implement because the pace at which products change, and markets change, are often rapid— industry has so far always been in a 'disturbed' state as new technologies change the rules of the game; natural ecosystems, by contrast, transform from type 1 to type 3 over thousands of generations of the species involved. How can we help push industry forward? The adoption of open standards can help here, so that components are more interchangeable between products and industries— this helps manufacturing systems develop long-term stability standards needed for building webs of interdependencies. Likewise less dependence on new cutting-edge technologies makes it easier to fit into existing webs. An important corollary of 'Waste = Food' that Janine Benyus makes is "don't draw down resources, live off the interest." It is a financial analogy, describing how mature (type 3) ecosystems don't need new income since they are living off of the interest from the great biological wealth they have acquired over time. Mining or harvesting too much of the world's existing natural resources is like spending the capital you're trying to live off the interest of, and it will catch up to you.

3 **Evolve Solutions, Don't Plan Them**

This means to design without authorship and to let go with dignity. Many designers may not be fond of this third principle because it strays from the traditional process of artists and *their* work. It is now about creating the right context for possibilities to emerge. As Jeremy Fauldi explains, the most direct example is genetic algorithms. Their huge success has proven the usefulness of this technique and principle. This in turn falls back to the idea of design being iterative and continuous. That is making multiple prototypes, user-testing them to find the favorites and most successful, then mixing and matching elements from each to create another generation of

prototypes which are in turn user-tested, ad infinitum. Incidentally, this is the method advocated by IDEO, one of the most successful design firms in the world.

4 **Adapt to Changing Conditions, Adjust to the Here & Now**

This fourth principle directly applies to Darwinian evolution; true evolution in the sense that a design is never done, it is only a means of adaptation. As Janine Benyus says, effective adaptation requires organisms to be information-driven, with local expertise. It also requires timely expertise. Species that range across dramatically different habitats must adjust themselves to the new locales, and those that stay in the same place but whose habitat changes (say, from summer to winter) adjust as well; i.e. hibernation. In the product world this means customizing for different users and different circumstances, to extend the product life-cycle. In more advanced implementations, it means the products adjust themselves without need for user intervention.

5 **Respect Diversity, Diversify to Fill Every Niche**

Respect diversity as a tenet can be very broad, covering a global level but it can also be scaled down to be compared to the industry, market and product level. In regard to the global level, it is showing a wide scope of respect and honor to all cultural, ethnic, racial, sexual, religious and spiritual diversity of beings within the context of individual responsibility. To respect and maintain biodiversity or a diversity of living species for a chance to change and evolve through natural selection is key.

On the market level, traditional industry already adapts to this. However, on the product level, mass-customization does a similar thing. The biomimetic-design lesson here ties in with the second principle, 'Waste = Food.' It is to find untapped niches where waste is being created, where it could instead be used as a resource. Smart manufacturers close their own resource loops; smart entrepreneurs close other peoples' loops. Solving a problem using a single solution, with no diversity, may make it vulnerable to outside influences.

6 **Self Appropriate Technologies**

This sixth principle is fairly simple: to use the right tools for the right job. This ensures time and cost efficiency and it also prevents the act of re-design. This also ties in with the first and second principles, 'Self-Assembly from the Ground Up' and 'Waste = Food.' In self-appropriating technologies, it confirms less waste which means less cleanup; less conflict; fewer costs.

7 **Be Resourceful**

Being resourceful may seem like another fairly broad principle to apply, but generally speaking it encompasses gathering and minimizing efficient energy and materials needed to produce a successful design solution. In regard to *gathering* efficient energy and materials, you do not necessarily need to study nature to get the importance of this, but it has a cornucopia of strategies you may have never tried. For example, ants have been studied to improve shipping schedule algorithms, plant leaves have been studied for solar energy absorption, mollusks have been studied for building shells out of seawater without even moving. The list goes on....

As for *minimizing* energy and materials to be resourceful, nature has an abundance of great examples. Plants and animals always try to use material and energy efficiently, because for them energy and material costs are the only costs. Successfully minimizing mass and energy use requires thorough optimization to the problem at hand, so organism structures are highly information-driven. On the other hand, industry's costs are primarily financial, so it usually finds it easier to simply use more material or energy than spend the extra time researching how to use it well. Yet, minimalist designs can be the most successful and cost-effective in the industry.

8 **Optimize Rather than Maximize**

Optimize rather than maximize as a concept focuses on creating designs that are multifunctional, always fitting form to function. This is general systems-thinking advice, but Benyus points out its ubiquitousness in biology. Creatures always have to balance multiple cost/benefit dimensions, there are no single-minded goals like being bigger or faster. A quick rule of thumb here is perform as many functions with as few components as possible, tying in the seventh principle of 'Be Resourceful' when it comes to selecting and gathering your materials. It is a good exercise to explicitly lay out all the factors you are trying to balance and organize. For instance, graphic designers can maximize the number of pages in a piece or the size of the paper which will probably allow for a more easily achieved eye-catching composition and attract more viewers; yet the functional design of the piece may be compromised if it is now too large for users. Always remember to optimize all variables.

9 **Use Life-Friendly Chemistry**

This principle, from both Benyus and Vogel, is fairly self-explanatory. Benyus describes the way we manufacture products is by 'heat, beat, treat.' She claims it has become the de-facto slogan of our industrial age; it is the way we synthesize just about everything. Nature, on the other hand, cannot afford to follow this strategy. Life cannot put its factory on the edge of town; it has to live where it works. As a result, nature's first trick of the trade is that nature manufactures its materials under life-friendly conditions— in water, at room temperature, without harsh chemicals or high pressures.

10 **Organize Fractally**

This tenth principle, organize fractally, looks at self-similarity in the way of planning for several different scales at once. Fibonacci spirals do not occur all over the place in nature because they are pretty, they occur all over because they are an algorithm that allows perpetual growth to any size without having to readjust or plan ahead. Fractal structures do not have to be as 'smart' as other structures which require different planning for different scales. This ties in with design having form and multi-functionality.

11 **The Entire System is Greater than the Sum of Its Parts**

People tend to design one function at a time, creating separate elements for each task and then creating the product by assembling all the pieces. There are many advantages to this, but in these products the whole will only be the sum of its parts. One of the hallmarks of complex systems is 'emergent phenomena,' the fact that the whole is greater than the sum of its parts. An example of 'emergent phenomena' is looking at how an individual bee has a small brain and simple behavior, but a swarm of bees is a sophisticated organism all its own. Emergent phenomena are hard, if not impossible to predict, and in the built world mostly happen by accident. However, designing with it in mind cannot only help avoid unintended consequences, but can open new opportunities— the democratizing force of the internet being a prime example. The key to this principle is designing lots of little, simple things that together can do sophisticated things; this can be a biomimetic design tool because it lets you build robust systems without infrastructure, build smaller and smarter stuff without super-high technology.

12 **Leveraging Interdependence, Feedback Loops**

Inter-relatedness and leveraging interdependence systems relies on learning the lessons from the ecosystems that we are a part of. This principle basically outlines what the biomimetic + graphic design process tries to do. We need to learn how to work with the cycles of the sun, water, wind, and geothermal energy rather than depleting finite resources that can be more effectively used elsewhere. In doing this, we can help to create a continuous locally attuned feedback loop that allows for the renewing of resources, recycling of all materials, and self-organizing of systems; all of which allows the fostering of cooperative relationships— the thirteenth design principle of nature. Natural ecosystems are able to sense boundaries and changing conditions, whereas humans are not so well adapted in doing. It is crucial that we look to these systems and feedback loops in order to solve our design problems in the most economical fashion.

13 **Foster Cooperative Relationships**

Just as in a natural ecosystem where one organism lives off another, providing the nourishment it needs to survive; graphic designers use print manufacturers to ensure their jobs and designs survive. It is using the same cycle of give and you shall receive. Both need each other in order to survive within the creative design industry. So, fostering cooperative relationships means we need to encourage creative thinking and cultivate relationships with other designers and manufacturers in the industry in order to keep this continuous cycle going. For instance, a stock photography company allows a printing shop to give its clients (graphic designers) access to its database account. A client can use any photograph as long as it uses the printing shop for printing. In turn, the stock photography company receives more revenue/exposure, the printer receives more services, and the client receives complementary or reduced-cost photos. It is actively seeking out a relationship to ensure positive business practices to get things done, benefiting all in the process.

14 **Don't Foul your Nest**

This last principle is another genius idea of Benyus. 'Don't foul your nest' is saying that in the grand scheme of things, do not use or design with harmful materials or effluents. Do you really want to live in a home that gives off harmful gases such as formaldehyde or dioxins? This sounds simple and obvious, but if engineers, architects, and other builders actually started following this principle alone, it would cause a revolution. This also refers to the design in sense that you should not 'foul your design' with any unnecessary components.

2.3 Design

2.3.1 Methodology

Designers are visual communicators. In order to create, we have to go through a process. It requires being innovative, meticulous and resourceful, taking each project from initial concepts to a final design solution. In the simplest of terms, we take a design problem, generate ideas through sketching and brainstorming and implement the best idea to produce a successful design solution.

However, design is not entirely about juxtaposing images and text to produce content in relation to the context of the problem. It has the power to do more. There is a common misconception among the general public (non-designers) who may not be aware of the methodology of graphic design or what graphic designers do. Some may think that all graphic designers do is make and print *stuff* that will only end up in landfills as waste. This is such a negative outlook to have because then every designer would ask themselves, "Why am I designing this if it is just going to end up in the trash?" Today we have the power to change that negative outlook and turn it into something positive. Take that piece of 'trash' and see how it can better fit within the larger ecosystem, creating conditions conducive to life and benefiting society rather than hindering it from reducing our carbon footprint.

In order to explore graphic design as a strategic process to assist societal problems, one needs to think very differently in terms of multidisciplinary design teams and working directly within his/her local communities and cultural organizations. This all relates back to the act of responsible design within modern practices.

While this new process affects the graphic design methodology by instituting the use of natural processes, principles and influences to promote change within critical social issues; the role of good communication design is just as relevant. Herein lies an incredible opportunity for graphic designers to illustrate his/her social relevance, influence, and creativity by using biomimicry within one's process.

2.3.2 Natural Proportions

Natural proportions and systems found within nature are instrumental to examine the similarities and differences between modern design practices versus nature's design practices. The natural proportional system that was examined initially was the golden section. Within the context of the man-made environment and the natural world there is a documented human cognitive preference for golden section proportions throughout recorded history (Elam, Geometry of Design). Some of the earliest evidence of the use of the golden section rectangle, with a proportion of 1:1.618, is documented in the architecture of Stonehenge built in the twentieth to sixteenth centuries, B.C.E. Further documented evidence is found in the writing, art, and architecture of the ancient Greeks in the fifth century, B.C.E. Later, Renaissance artists and architects also studied, documented, and employed golden section proportions in remarkable works of sculpture, painting, and architecture. In addition to man-made works, golden section proportions can also be found within nature through human proportions and the growth patterns of many living plants, animals and insects. The contour spiral shapes of shells reveal a cumulative pattern of growth and these growth patterns have been the subject of many scientific and artistic studies.

A man by the name of Gustav Fechner, a German psychologist in the late nineteenth century, developed a curiosity about the golden section and began investigating the human response to the special aesthetic qualities of the golden section rectangle. Fechner's curiosity was based on evidence of a cross-cultural archetypal aesthetic preference for golden section proportions. Fechner limited his experience to the man-made world and began by taking the measurements of thousands of rectangular objects, such as books, boxes, buildings, matchbooks, newspapers, etc. He found that the average rectangle ratio was close to a ratio known as the golden section, 1:1.618, and that the majority of people preferred a rectangle whose proportions were close to the golden section. Fechner's thorough yet casual experiments were repeated later in a more scientific manner by Charles Lalo in 1908 and still later by others, and the results were remarkably similar (Elam, Geometry of Design).

"The power of the golden section to create harmony arises from its unique capacity to unite different parts of a whole so that each preserves its own identity, and yet blends into the greater pattern of a single whole."
György Doczi, *The Power of Limits,* 1994

The growth patterns of shells are logarithmic spirals of the golden section and occur because of these natural algorithms. The pentagon and pentagram also share golden section proportions and can be found in many living things such as the sand dollar and snowflake. The interior subdivisions of any two lines within a star pentagram are the golden section proportion of 1:1.618.

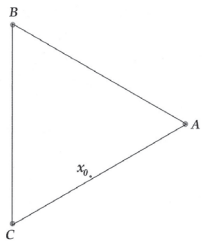
As far as performing a visual analysis of graphic design in relation to natural proportions, the understanding is that there are underlying principles of geometry that exist in both. These principles bring a sense of logic and compositional cohesiveness to a creative work, whereby each element of the work has a visual sense of belonging. By revealing some sort of geometry, grid system, and proportions it is possible to better understand the intent and reasoning of designers' work. It gives insight into the process of realization and a rational explanation for many decisions, whether the use of organizational geometry is intuitive or deliberate, rigidly applied or casually considered (Elam, Geometry of Design). This essentially proves that there is a reason for the way in which everything, whether in design or nature, works in the manner it does when in a cohesive, working system. There is a specific rationale, understanding and methodology behind each process.

Besides the golden section, another very important area to research are the naturally occurring fractals based on the Sierpinski triangle. Fractal, by definition, means a curve or geometric figure, each part of which has the same statistical character as the whole. Fractals are useful in modeling structures (such as eroded coastlines or snowflakes) in which similar patterns recur at progressively smaller scales, and in describing partly random or chaotic phenomena such as crystal growth, fluid turbulence, and galaxy formation. Fractals have a number of characteristic properties, and some of the best known examples of fractals possess the intriguing feature of self-similarity which is usually the result of a basic, natural algorithm process called *recursion.* Recursion occurs when a system receives input, modifies it slightly, and then feeds the output back into the systems as input. Fractals exhibiting self-similarity and recursion show the same structure on all scales. The term 'fractal' was first used by mathematician Benoît Mandelbrot in 1975. Mandelbrot based it on the Latin frāctus meaning 'broken' or 'fractured,' and used it to extend the concept of theoretical fractional dimensions to geometric patterns in nature.

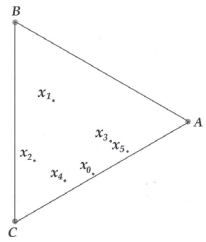
However, before Mandelbrot coined the term 'fractal,' there was an earlier Polish mathematician by the name of Waclaw Sierpinski who was studying fractal patterns, just in a different manner and by a different name. In 1915, Sierpinski published the first set of pictures of what is now known as the Sierpinski triangle. The Sierpinski triangle is composed of three smaller triangles, each of which is just a copy of the original Sierpinski triangle.

What Sierpinski was trying to illustrate was that this process may be repeated *ad infinitu:* each of the smaller triangles consists of three scaled down copies of itself. If you look closely, you will see that any one of the smaller triangles in the Sierpinski triangle is the original triangle. One of the remarkable features of fractals, like the Sierpinski triangle, is that they can often be produced using very simple instructions or algorithms. The novelty of these instructions is that they are based on choosing a sequence of random numbers.

A random iteration algorithm for obtaining arbitrarily close approximations to the Sierpinski triangle is as follows:



1 Begin by choosing an equilateral triangle in a plane
2 Label the vertices A, B, C and pick a point inside the triangle (outside will work as well— the end result is just the same)
3 Now randomly choose one of A, B, or C. If say B is chosen, move the point halfway to vertex B and mark the point. Similarly, if A is chosen, move the point halfway to A, and the same for C.
4 Now, repeat the process to obtain a sequence of points that can be plotted



Put simply:

1 Begin by choosing an equilateral triangle in a plane
2 Shrink the triangle to ½ height and ½ width, make three copies, and position the three shrunken triangles so that each triangle touches the two other triangles at a corner
3 Repeat step 2 with each of the smaller triangles

The actual fractal is what would be obtained after an infinite number of iterations.

The algorithm for constructing the Sierpinski triangle was based on fixing an equilateral triangle or, more precisely, fixing the vertices of that triangle. It is natural to modify the algorithm a little by replacing the triangle with a square or indeed by any one of the regular polygons. For instance, suppose we had initially chosen a regular pentagon in the plane. After choosing an initial point inside of it, you could have defined the algorithm by making random choices of vertices and at each stage of the iteration, move halfway towards the vertex. Thus creating the algorithm and fractal pattern, which are both found naturally recurring throughout nature.

The purpose of showing fractal patterning and the Sierpinski triangle is to demonstrate that patterns and design systems within nature do not occur unmethodically over time, but due to the naturally occurring algorithms. The ubiquity of self-similarity in nature hints at this underlying order and algorithm, and suggests ways to enhance the aesthetic composition of human-created forms and perhaps their structural composition as well.

Relating this to the surface mimicry of animals, if one was to take a close look at the hide, skin, or texturing patterns of animals, one would find that it is a structured, well thought-out pattern based upon a logical grid system and fractally organized algorithms. One of the best known and most beautiful system of patterning seen in nature is the hexagonal conformations most notoriously connected with the honey bee's cell. The hexagonal symmetry in plants and animals "doth neatly declare how nature Geometrizeth and observeth order in all things," (Thompson, *On Growth and Form*).

Natural patterns are fundamental to us getting along in the world. By appreciating natural patterns, we better understand the basic patterns we intuitively recognize, thus we better know how to communicate. Both graphic design and nature rely on these intuitive pattern systems to transfer visual messages and stimuli, knowing the end user will perceive what these specific patterns signify, thus communicating the message successfully. Design, in the broadest sense, is the ability to communicate through an intuitive sense of pattern. It is the difference between lucid communication and meaningless noise. It is the basics of conscious awareness of patterns that brings cohesion to a sometimes chaotic landscape by allowing us to see contrast as well as similarity. It is fundamental that designers recognize these patterns during the observation stage of the biomimetic design process in order to better adapt with nature, since it is not just people who have these instinctive and intuitive pattern recognition sensibilities. It is necessary to take a closer look at how organisms live, function and communicate. In doing this, designers will come to realize that creatures have the same intuitive intelligence as humans do that allows them to recognize certain symbols. For instance, bees find honey down a diverging maze by navigating colonized directional patterns after a few attempts. Chimpanzees use symbols not only to identify objects but also to describe conceptual impressions of the world around them. In studying chimpanzees, it was noticed that they even use rudimentary language to communicate and say 'yes' and 'no' in response to someone talking to them over the phone.

Pattern awareness cues designers to make and select the most appropriate relationships that specifically describe a client's unique attributes, while embedding universal design concepts and principles. Thus resulting in elegant, clear, recognizable design understood by all cultures.

In talking about basic communication patterns and techniques, nature uses mimicry as its form and technique when it comes to particular pattern making and design. Mimicry is the act of copying properties of familiar objects, organisms, or environments in order to realize specific benefits afforded by those properties. In nature, mimicry refers to the copying of certain properties to hide from or deter other organisms. This is where animal camouflage, or surface mimicry, plays a significant role in evolution and survival of the fittest.

However, camouflage is not strictly about chameleons changing the color of their skin in an instant; it is also about polar bears being white and not brown like grizzlies. In order to understand animals with this ability of mastering the art of deception, it is important to know why animals have this cunning ability. A major concern of animals is to protect themselves from predators in order to survive, reproduce and pass off their genes to a future generation. Many animals have evolved adaptations known as 'anti-predator devices' and use camouflage to blend in with their natural environments and patterns in an attempt to be unrecognizable by predators. However, there are exceptions: animals which are dangerous to eat (i.e. wasps) advertise with warning coloration.

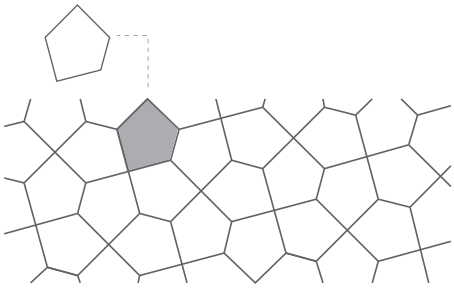
Animal camouflage can relate to design in the sense that mimicry refers to copying properties of familiar objects, organisms or environments in order to improve the usability, likability, or functionality of an object. Design and nature create with three forms of mimicry in mind: surface, behavioral, and functional. Surface mimicry (camouflage) is making a design *look* like something else; Behavioral mimicry is defined as making a design *act* like something else; Functional mimicry is defined as making a design *work* like something else.

In this thesis tessellation patterns were also thoroughly researched and implemented. The word tessellation means to fit or join polygons into flat, continuous patterns. A tessellation pattern is created by joining three or more sides of a set of polygons. The point where the sides meet is called a vertex; the sum of the angles around a vertex equal 360°. Regular tessellations are created by combining regular, congruent polygons in a uniform manner. The only three regular, congruent polygons that can possibly be used in regular tessellations are the triangle, the square and the hexagon, sometimes pentagon because only they have interior angles that divide evenly into 360°. A semi-regular tessellation is uniform and consists of more than one type of regular polygon. There are uniform/nonuniform and periodic/non-periodic tessellations. In a uniform tessellation all vertices are congruent and the organization of polygons around each vertex is the same. In a periodic tessellation a group of regular polygons can be moved to a new position within the tessellation, where it will fit together exactly with a similar group of regular polygons. The hexagonal honey bee cell is one of the best known tessellation patterns and the interest here is looking into how using these joined or fit polygons can create a continuous pattern design, similar to mosaic tiling, and how they can relate to surface mimicry.

All share similar methodologies and principles: the use of symmetry, the Sierpinski triangle, and the concept of implementing natural algorithms and self-similarity that occur within nature. It is organizing fractally, while also optimizing the amount of materials needed to create these patterns.

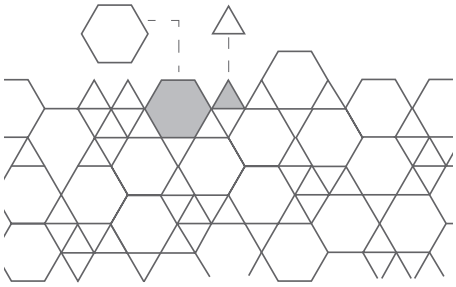
Regular Tesselation Pattern

(using the same pentagonal shape throughout)



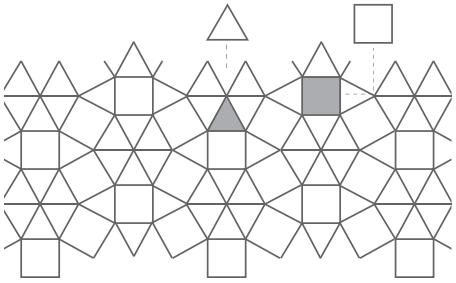
Semi-Regular Non-Uniform Periodic Pattern

(using 2 polygonal shapes: hexagon and triangle)



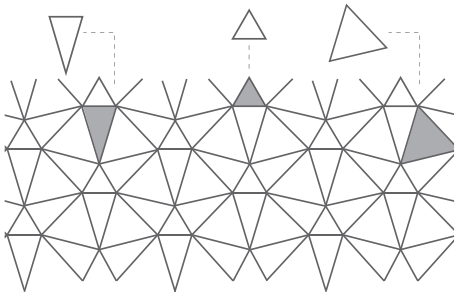
Semi-Regular Non-Uniform Non-Periodic

(using 2 polygonal shapes: triangle and square)



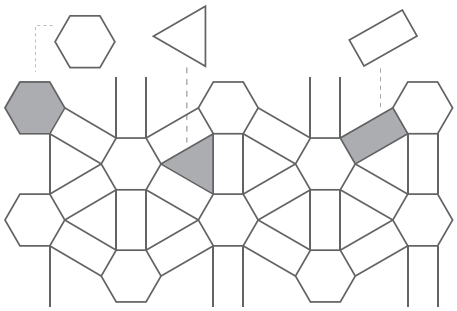
Regular Uniform Non-Periodic Pattern

(using the same triangular shape throughout)



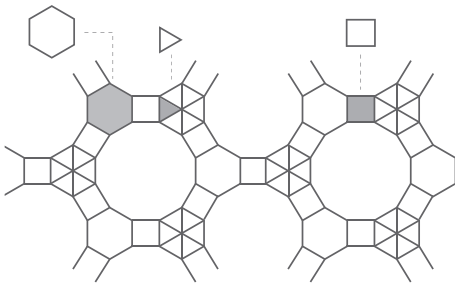
Semi-Regular Non-Uniform Non-Periodic

(using 3 polygonal shapes: hexagon, triangle, rectangle)



Semi-Regular Non-Uniform Periodic Pattern

(using 3 polygonal shapes: hexagon, triangle, square)



2.3.3 Information Graphics and Color Theory

In representing and communicating information it is important to know the basic color variations and preferable styles. In order to create the graphic solutions within the print application (tessellation patterns, identity mark, infographic) information graphics and the works of Edward Tufte were closely examined. In applying color theory to nature and graphic design, it has the potential to essentially turn a 'bad' design into one that makes cohesive sense, bringing about order and harmony within a piece. For instance, it has been proven that color spots against a light grey or muted field highlight data and information, while also helping to achieve an overall harmony.

When it came to choosing a palette of colors to represent and illuminate information related to nature, it was only natural to *use colors found in nature,* especially those on the lighter side, such as blues, yellows, greens and greys of sky and shadow. The colors that were chosen for the biomimicry + design identity mark, as well as the color of the pages within the print application, were selected to work with this theory of color logic and styles. Nature's colors are familiar and coherent, possessing a widely accepted harmony to the human eye— and their source has a certain definitive authority (Tufte, *Envisioning Information*). In all fifty or so systems of color organization, every color is located in three spaces: described by hue, saturation and value. These three dimensions were considered when creating the graphic solutions and applied whenever it was appropriate to do so. Color can also act as a natural quantifier, with a perceptually continuous (in value and saturation) span of incredible fineness of distinction. Here, this notion was applied by showing the deeper or darker hues of the natural colors slowly fading away to the lighter colors seen at the surface. This value scale was shown in the green tone seen in the identity mark, naturally progressing from light green to dark. It is important to note that everything is related to context and to remember the gestalt principles of perception in that the entire system is greater than the sum of its parts. Perhaps even more interesting is the way in which colors can be applied to information graphics, arranging colors next to each other in a way that makes two different colors look alike, merely by choosing the correct color as the background. Josef Albers, a master of color theory, describes this as a subtraction of color: "Repeated...experiments with adjacent colors will show that any ground subtracts its own hue from colors which it carries and therefore influences," (Albers, *Interaction of Color*). So the question here is, can these interactions of color benefit information design and communicate the message in a more visually and aesthetically pleasing manner to its audience? Color in itself is subtle and exacting and the process of translating perceived color marks into quantitative data ultimately resides in the viewer's mind and experience. (Tufte, *Envisioning Information*). So as it stands with design and color relationships, even simple visual effects in choosing the correct color hue can involve a simultaneous complexity of design issues.

2.3.4 Layout Essentials and Grid Systems

In the creation of the final print application and book, it was instrumental to research a variety of complex layouts and grid systems within both natural and human (graphic) design. A grid in design is used to organize space and information in a logical and aesthetically pleasing manner for the viewer and reader. It helps to shape the entire project, mapping out a detailed plan to maintain order within the information. Although grids have been used for centuries, many graphic designers associate grids with the Swiss. The rage for order in the 1940s led to a very systematic way of visualizing information. Decades later, grids were considered monotonous and boring— the sign of a "designsaur," (Trondreau, *Layout Essentials)*. Today, and within modern design practices, grids are again viewed as essential tools, relied upon by all designers; professional and novice alike. It is important to keep in mind that the most essential percept of communication is to relate one's typography and layout to the material and context of information one is trying to articulate to its audience in a consistent fashion.

There are a variety of grid systems to utilize (including the golden section and ratio system) ranging from a single column and two column grid system to a modular and hierarchal grid system. All systems, however, make use of the same components: columns, margins, baseline grids, modules, etc. It is necessary to first consider and analyze all of the parts of the piece in order to place them correctly on the page. For the final print application of this thesis project, a careful and approximate examination of all parts and materials were taken into consideration from typography and body text to the flow of images and spatial zones to provide diversity. The content was the most important aspect and to highlight it was obviously first and foremost, with the images closely following. The order and sequencing of pages was determined in the way that made the most sense for the reader, using color to differentiate space and sections ultimately setting the tone of the book.

2.3.5 Universal Design Principles & Elements

When looking at graphic design and contemporary trends, it is apparent complexity is increasing because of the expansion of new technologies. With technological and societal advances, emphasis is now placed on new applications including tablets, mobile devices, e-books, etc. The major focus is no longer on pure form generation which has been the case in the past, but instead, is placed on other elements such as device, user needs and involvement, affordability, resources, and environmental concerns. Although, this is not to say that form generation is not an important aspect to the field anymore because it is still one of the most important facet of graphic design; there are just other elements that designers today need to be aware of that designers in the past did not. For instance, web designers now need to be aware of responsive design, ensuring that their design not only looks good on a desktop, but on smaller scales such as tablets and smartphones.

Although these digital technologies afford greater freedom and flexibility, they can often cut short the creative window for concept development and creative thinking. People, places, thoughts and things become familiar through repeated exposure. There is much temptation to turn directly to the computer and type in a Google search. This often results in images or ideas that are tired and trite. It is important that designers do not get trapped in the technological pitfall of leaving little to no imagination or bypassing the creative brainstorming processes of sketching and ideation.

Although every designer has his/her own creative process, all are based on the foundation of knowing the basic elements and principles of design including balance, rhythm, proportion, dominance, unity, form, shape...However, there are other principles that designers should remind themselves of such as Hick's Law, Ockham's Razor, etc. Graphic design is a discipline directed toward the development and distribution of information in a visually creative way. Instead of the all of the focus being directed towards distributing the information in the best manner to please clients; the larger focus should now be how can one experiment with this visual language, while integrating nature in a way that still conveys a message. This is in hopes of ultimately producing a form of universal design. Good design has often been labeled as being based on a type of logic, grid system and structure with a resolved plan. For instance, a well designed logo is usually a progression of ideas and forms, sketching and re-sketching until the final design is achieved. What needs to be stressed is that there is a level of importance in sketching and process that unfortunately in modern design practices with the acceleration of technology, is getting lost due to immediate satisfaction with internet access. It is important to reassess and look back to the basic principles found within nature in order to move forward. In doing this, it will ensure that the work designers produce in the future will continue to be successful, timeless, and sustainable.

2.3.5 14 Universal Principles & Elements

The following 14 Universal Design Principles and Elements are an extension of Nature's 14 Design Principles to show how both relate and correspond to each other within the biomimetic design process.

Each design principle falls into 1 of the 3 categories:

Form

Systems

Thinking

Category		
		Form
	1	Form Follows Function
	2	Mimicry
	3	Self-Similarity
	4	Symmetry
	5	Uniform Connectedness
		Systems
	6	Convergence
	7	Feedback Loop
	8	Hick's Law
	9	Hierarchy of Needs
	10	Life Cycle
		Thinking
	11	Depth of Processing
	12	Five Hat Racks
	13	Mental Model
	14	Ockham's Razor

Form **The following design principles pertain to the form and physical shape of a(n) object(s)**

1 **Form Follows Function**

Beauty in design results from purity of function. The form follows function axiom is interpreted in one of two ways— as a description of beauty or a prescription for beauty. The descriptive interpretation is that beauty results from purity of function and the absence of ornamentation. The prescriptive interpretation is that aesthetic considerations in design should be secondary to functional considerations. When making design decisions, focus on the relative importance of all aspects of the design— form and function— in light of the success criteria.

2 **Mimicry**

The act of copying properties of familiar objects, organisms, or environments in order to realize specific benefits afforded by those properties. In nature, mimicry refers to the copying of certain properties to hide from or deter other organisms. For instance, the viceroy butterfly mimics the less tasty monarch butterfly to detect predators. In design, mimicry refers to copying properties of familiar objects, organisms or environments in order to improve the usability, likeability, or functionality of an object. There are three basic kinds of mimicry in design: surface, behavioral, and functional. Mimicry is perhaps the oldest and most efficient method for achieving major advances in design. Consider surface mimicry to improve usability, ensuring that the perception of the design corresponds to how it functions or is to be used.

3 **Self-Similarity**

A property in which a form is made up of parts similar to the whole or to one another. Many forms in nature exhibit self-similarity and as a result it is commonly held to be an intrinsically aesthetic property. Natural forms tend to exhibit this at many different levels of scale, whereas human-created forms generally do not. This naturally occurring self-similarity is usually the result of a basic algorithm process called *recursion*. Recursion occurs when a system receives input, modifies it slightly, and then feeds the output back into the systems as input. The ubiquity of self-similarity in nature hints at an underlying order and algorithm, and suggests ways to enhance the aesthetic composition of human-created forms and perhaps their structural composition as well. Consider self-similarity in all aspects of design: story boarding, visual displays and structural compositions. The reuse of a single, basic form to create many levels of metaforms mimics nature's tendency towards parsimony and redundancy and can create interesting organizations at multiple levels of scale.

4 **Symmetry**

A property of visual equivalence among elements in a form. Symmetry has long been associated with beauty, and is a property found in virtually all forms in nature. It can be seen in the human body as well as plants and animals. Symmetry in natural forms is largely a function of the influence of gravity and the kind of averaging of form that occurs from merging genetic information in reproduction. There are three basic aspects of symmetry: reflection, rotation, and translation. Use symmetry in design to convey balance, harmony, and stability.

5 **Uniform Connectedness**

Elements that are connected by uniform visual properties, such as color, are perceived to be more related than elements that are not connected. This is one of the *Gestalt principles of perception,* asserting that elements connected to one another by uniform visual properties are perceived as a single group or chunk and are interpreted as being more related than elements that are not connected. There are two basic strategies for applying uniform connectedness in design: common regions and connecting lines. Common regions are formed when edges come together and bound a visual area, grouping the elements within the region. Connecting lines are formed when an explicit line joins elements, grouping the connected elements. Use uniform connectedness to visually connect or group elements in a design. Employ common regions to group text elements and clusters of control elements, and connecting lines to group individual elements and imply sequence.

Systems

The following design principles pertain to entire systems of design and how they function over time

6 **Convergence**

A process in which similar characteristics evolve independently in multiple systems. Natural or human-made systems that best approximate optimal strategies afforded by the environment tend to be successful, while systems exhibiting lesser approximations tend to become extinct. This process results in the convergence of form and function over time. The degree of convergence in an environment indicates its stability and receptivity to different kinds of innovation. Consider the level of stability and convergence in an environment prior to design. Stable environments with convergent system designs are receptive to minor innovations and refinements but resist radical departures from established designs. Unstable environments with no convergent system designs are receptive to major innovations and experimentation, but offer little guidance as to which designs may or may not be successful.

7 **Feedback Loop**

A relationship between variables in a system where the consequences of an event feed back into the system as input, modifying the event in the future. Every action creates an equal and opposite reaction. When reactions loop back to affect themselves, a feedback loop is created. All real-world systems are composed of many such interacting feedback loops— animals, machines, businesses, and ecosystems. There are two types of feedback loops: positive and negative. Positive feed-back amplifies system output, resulting in growth or decline. Negative feed-back dampens output, stabilizing the system around an equilibrium point.

8 **Hick's Law**

The time it takes to make a decision increases as the number of alternatives increase. Hick's Law states that the time required to make a decision is a function of the number of available options. It can be used to estimate how long it will take for people to make a decision when presented with multiple choices and has implications for the design of any system or process. Keep Hick's Law in mind when designing systems that involve decisions based on a set of options to increase efficiency, resulting in less waste.

9 **Hierarchy of Needs**

In order for a design to be successful, it must meet people's basic needs before it can attempt to satisfy higher-level needs. This principle specifies that a design must serve the low-level needs (it must function) before the higher-level needs (creativity) can be addressed. Good design follows the hierarchy of needs principle, whereas poor designs may attempt to meet needs from the various levels without building on the lower level of hierarchy first which results in a waste of resources. There are five key levels of needs: functionality, reliability, usability, proficiency, and creativity. Functionality needs have to do with meeting the most basic design requirements. Reliability needs have to do with establishing stable and consistent performance. Usability needs have to do with how easy and forgiving a design is to use. Proficiency needs have to do with empowering people to do better things than they could previously. Creativity is the level in the hierarchy where all needs have been satisfied and people begin interacting with the design in innovative ways.

10 **Life Cycle**

All products progress sequentially through four stages of existence: introduction, growth, maturity and decline. This roughly corresponds with the natural life cycle of birth, adolescence, adulthood and death. For example, a new tablet is envisioned and developed; its popularity grows; after a while, its sales plateau; and then finally, the sales decline. Understanding the implications of each of these stages allows designers to prepare for the unique and evolving requirements of a product over its lifetime. The introduction stage is the official birth of the product. The growth stage is the most challenging stage where most products fail. The maturity stage is the peak of the product life cycle. Finally, the decline stage is the end of the life cycle. Always consider the life cycle of a product when planning and preparing for the future. Always work closely with early adopters to refine and tune products in the introduction phase. During the growth phase, focus on scaling product supply and performance. Also focus on customer satisfaction through performance enhancements and improved support during the maturity phase. Then, once you hit the decline phase, focus on facilitating the transition to next generation products.

Thinking

The following design principles pertain to how we process information when visually communicating a message

11 **Depth of Processing**

A phenomenon of memory in which information that is analyzed deeply is better recalled than information that is analyzed superficially. Thinking hard about information improves the likelihood that the information will be recalled at a later time. This phenomenon of memory results from the two ways in which information is processed known as maintenance rehearsal and elaborative rehearsal. Maintenance rehearsal simply repeats the same kind of analysis that has already been carried out. For instance, someone repeats a phone number aloud back to the themselves to help them remember; no additional analysis is performed on the phone number. Elaborative rehearsal involved a deeper, more meaningful analysis of the information. For instance, when someone reads a passage from a book aloud and then has to answer questions about the meaning of it; additional analysis as to word and sentence meaning require additional thought. Consider depth of processing in design contexts where recall and retention of information is important. Use unique presentation and appropriate tools to engage people to deeply process the information relevant to an audience.

12 **Five Hat Racks**

There are five ways to organize information: category, time, location, alphabet, and continuum. The organization of information is one of the most powerful factors influencing the way people think about and interact with a design. The five hat racks principle asserts that there are a limited number of organizational strategies, regardless of the specific application, so optimization of each category in the simplest manner is key in users understanding and processing information.

13 **Mental Model**

People understand and interact with systems and environments based on mental representations developed from experience. They do this by comparing the outcomes of their mental models with real-world systems and natural environments. With regard to design, there are two basic types of mental models: mental models of how systems work (system models) and mental models of how people interact with systems (interaction models). Design with people's differing interaction models in mind. If there is a standard mental model for how something works, try to design leveraging that model.

14 **Ockham's Razor**

Given a choice between functionally equivalent designs, the simplest design should be selected. Ockham's razor asserts that simplicity is preferred to complexity in design. Many variations of the principle exist, Aristotle explaining it as "Nature operates in the shortest way possible." Implicit is the idea that unnecessary elements decrease a design's efficiency and increase the probability of unanticipated consequences. Use Ockham's razor to evaluate and select among multiple, functionally equivalent designs.

2.4 Materials

Modern design emerged in response to the Industrial Revolution, when reform-minded artists and artisans tried to impart a critical sensibility to the making of objects and media. Design took shape as a critique of industry, yet it gained its mature and legitimate status by becoming an agent of machine production and mass consumption. In the 1940s and 1950s, organic forms and materials provided designers with a humanist vocabulary that affirmed society's place within the natural world. By the end of the century, a new 'organicism' had emerged, as nature itself was transformed by a host of technologies (Lupton, *Skin: Surface Substance + Design*). Although the Industrial Revolution gave rise to modern capitalism today and it greatly expanded the possibilities for the material development of humankind, it does so at a severe price. The electronic offshoots of the Machine Age threaten to dissolve some of nature's most valuable assets. Since the mid-eighteenth century, more of nature has been destroyed than in all prior history. While industrial systems have reached pinnacles of success, able to muster and accumulate human-made capital on vast levels, natural capital, on which civilization depends to create economic prosperity, is rapidly declining, and the rate of loss is increasing proportionate to gains in material well being.

Every consumer product comes from the Earth and returns to it in one form or another. We have increased our supply of material goods and services at the direct expense of natural services. As Janine Benyus says, 'heat, beat, treat' has become the de-facto slogan of our industrial age; it is the way we synthesize just about everything. Nature, on the other hand, cannot afford to follow this strategy.

Benyus describes it by saying life cannot put its factory on the edge of town; it has to live where it works. As a result, nature's first trick of the trade is that nature manufactures its materials under life-friendly conditions— in water, at room temperature, without harsh chemicals or high pressures. Despite what we would call 'limits,' nature manages to craft materials of a complexity and a functionality that humans can only envy. Nature has the innate capability to customize materials through the use of templates. In contrast, humans muddle by in using industrial chemistry with final products that are a mishmash of polymer-chain sizes, with most too long or too short to be of ideal use. Nature makes only what she wants where she wants and when she wants. There is no waste on the cutting-room floor. As designers, we are one step ahead in the right direction, using templates and grid systems in our designs to effectively and efficiently use the resources available to us. However, society as a whole tends to maximize when it perceives there is an inexpensive abundance of materials readily available to it. Yet the Earth has limits and boundaries, and there is a finite amount of resources at our disposal. It is important to see the entire system and become aware of costs to others when designing or choosing supplies. In terms of choosing supplies, in theory it has been known that picking an eco-material is a better move than picking an un-eco one. However, if a designer does not know why a material is eco, how to implement it correctly, or even if it actually is 'eco,' taking a typically shallow replacement approach can end up with impacts far worse than the things being replaced. This is where possessing the knowledge and skills of how to effectively select the right tools and materials is crucial. Relying on the sixth design principle of nature, *'S*elf-Appropriate Technologies,' will help to do so. As graphic designers, even though we cannot directly change how paper is manufactured, we can voice our concerns, suggest alternatives, and hope that people upstream and downstream catch hold of and implement our ideas. Today, we assume that the way we're doing it is the best way, but it might not be.

The fatal flaw of technologic and human thinking, especially in the years since the Industrial Revolution and WWII, is that modern technology is like a two-legged stool: "Our science was well founded in physics and chemistry, but flawed by a missing third leg— the biology of the environment." It is crucial that society and modern industries today recognize and understand our routine of over consumption and how it is detrimental for future generations. David Tilford in his article, "Sustainable Consumption: Why Consumption Matters" explains in the simplest way how we are over-consuming goods and services and negatively impacting natural ecosystems:

> Our cars, houses, hamburgers, televisions, sneakers, newspapers and thousands upon thousands of other consumer items come to us via chains of production that stretch around the globe. Along the length of this chain we pull raw materials from the Earth in numbers that are too big to even conceptualize. Tremendous volumes of natural resources are displaced and ecosystems disrupted in the uncounted extraction processes that fuel modern human existence. Constructing highways or buildings, mining for gold, drilling for oil, harvesting crops and forest products all involve reshaping natural landscapes. Some of our activities involve minor changes to the landscape. Sometimes entire mountains are moved.

Recognizing that we need to reduce our ecological and carbon footprint is the initial step towards a more sustainable future. An ecological or carbon footprint is defined as the amount of productive land area required to sustain one human being. As most of our planet's surface is either under water, there are only 1.9 hectares (about four football fields) of productive area to support each person today (grow food, supply materials, clean our waste). That might sound like a lot but our collective ecological footprint is already 2.3 hectares. This means that given the needs of today's human population, we already need 1.5 Earths to live sustainably. But this assumes all resources are divided equally. Those with the largest carbon footprint— the biggest consumers of global resources— are US citizens, who require 9.57 hectares *each* to meet their demands. If everyone in the world consumed at that rate, *5 Earths* would be needed to sustain the population. People in Bangladesh, in contrast, need just 0.5 hectares; for people in China today, the footprint is 1.36 hectares. Part of why the US carbon footprint is so large has to do with trade access to more than the country's balance of natural capital. Much of this natural capital comes from countries that have some resources but not much else from which to earn cash. Due to corruption, or desperation, many of those countries are selling off their resources quickly, regardless of the long-term consequences. After six months, 99% of the resources to make things we use is converted to waste— disposed of as finished goods, but mostly as processed waste.

The main point to understand about the selection of tools and materials within the biomimetic design process is that whatever is naturally here is all we have. Whatever humans make does not go 'away.' We need to eliminate the concept of waste which means to design things— products, packaging and systems— from the very beginning on the understanding that waste does not exist. Nature has relied on this mindset and because of that, has flourished on this planet for billions of years. Yet, this may not be the case in the near future if we continue our bad habits. Ways to shift these bad habits towards good ones would be to constantly ask oneself these fundamental questions: Does it make us or the planet sick? (Don't do it!) Are you picking your material because it is the best one for your application or the same as it is always done before/your competitor is using it? Can we be happy without having more and more stuff?

2.5 Biomimicry and Corporations

Bringing biomimicry into every corporation around the world is a dream for biomimetic designers. In doing that, it would enable for more interdisciplinary team work where biologists would work with architects, designers, and CEO's, ultimately cultivating and fostering cooperative relationships around the globe. Today, business attitudes are already acting on this and implementing the biomimetic design process within their corporations.

The reason biomimicry is so important to integrate into businesses and corporations and why this topic is stressed is because of the power and ability these corporations have and hold in changing the perception of their consumers; which in turn has the power to generate change and the perception of society in general. In an interview with Janine Benyus, she explains why biomimicry now is so vital and why it is the key to bettering our future:

> We humans are at a turning point in our evolution. Though we began as a small population in a very large world, we have expanded in number and territory until we are now bursting at the seams. There are too many of us, and our habits are unsustainable. Having reached the limits of nature's tolerance, we are finally shopping for answers to the question: "How can we live on this home planet without destroying it?" Just as we are beginning to recognize all there is to learn from the natural world, our models are starting to blink out— not just a few scattered organisms, but entire ecosystems. A new survey by the National Biological Service found that one-half of all native ecosystems in the United States are degraded to the point of endangerment. That makes biomimicry more than just a new way of viewing and valuing nature. It's also a race to the rescue.

So, in order to act on this biomimetic design process in hopes for bettering the future, what is needed is a shift in perception, including a shift in the way we live and work within businesses. Many innovators are starting to grasp this concept. One of them is, Michael Pawlyn, a world renowned architect, established the architecture firm *Exploration* in 2007 to focus on environmentally sustainable projects that take their inspiration from nature and biomimicry. He recently published a book, *Biomimicry in Architecture*, that not only gives examples of where biomimicry has been used in corportions, but also answers some of the issues that naysayers raise. Pawlyn argues that a lot of the technology needed to make this integration of biomimicry within corporations happen is already available. In the book, he points to George Chan's sorghum brewery in Tsumeb, Namibia, which was built to deliver 'good beer, no pollution, more sales and more jobs.' It produced 12 products instead of simply just beer and these included the nutrient-rich alga spirulina, mushrooms grown in the spent grains and gas from an anaerobic digester which was used instead of burning wood. Pawlyn enthuses:

> For me, biomimicry is just one of the best sources of innovation to get to a world of zero waste because those are the rules under which biological life has had to exist. And it hasn't just existed in a really miserable, self-denying way, but in a celebrated, abundant and regenerative way. I think we need to move to a far more positive way of talking about the future. A lot of sustainable design has got very stuck in very familiar solutions and even familiar materials and forms, and so there's so much more to it. If you look beyond the nice shapes in nature and understand the principles behind them, you can find some adaptations that can lead to new innovative solutions that are radically more resource efficient. It's the direction we need to take in the coming decades.

2.5.1 Cross-Disciplinary Design Tables

One of the largest, contributing factors when integrating biomimicry into corporations is the use of cross-disciplinary design tables during creative brainstorming sessions. This is where innovators and professionals from all fields come together and sit down to discuss the potential biomimicry has in helping their businesses and corporations thrive in the marketplace and co-exist with the surrounding ecosystems. Two major design companies, IDEO and Smart Design, put biomimicry and BaDT's (Biologists at the Design Table) to the test, tackling design problems for real-world clients alongside biologists from the Biomimicry Institute. The magazine, *Fast Company* posted the following case studies and wanted to do a follow up/check in with both IDEO and Smart Design to see if they thought biomimicry as a new tool could help advance their businesses. Below is a section of the article from fastcompany.com, shown to best illustrate what the companies thought of the entire process:

Richard Graves, vice president of the community for the U.S. Green Building Council, said he was skeptical at first having IDEO take a biomimetic approach to redesign their organizational structure and if it would prove useful beyond just theory. "To be honest, I was not sure how much we would get that would be usable, but I see many ideas that can be explored and developed," he says. "I was surprised at how many of the ideas seem very practical and implementable." One particular solution that stood out to him was an idea to signal the health of USGBC chapters that was inspired by a pink flamingo: The "health" of the flamingo— or how much shrimp it eats— is outwardly reflected in the shade of pink of its feathers. "Having a simple, clear characteristic that reflects the health of an organization would be very useful in the chaotic world we live in," he says. "How to achieve this?"

Ultimately, Graves was impressed with the way biomimicry reframed their internal issues. " Biomimicry is a great tool to integrate into the design process of an innovative company or organization," he says. "We saw it as a way to have a different lens on challenges we have been working on for some time."

The second challenge focused on Smart Design's ideas for cities to conserve water as part of IBM's SmarterCity initiative. "IBM itself is no stranger to a biomimetic approach," says Ian Abbott-Donnelly of IBM Big Green Innovations, pointing to a recent computer-chip using the same self-assembling nanotechnology that builds snowflakes and seashells. But the fact that Smart Design was able to examine biomimicry at city-scale, using larger principles based on an ecosystem's feedback loops, proved that biomimicry can work for their initiative working at the civic level. "This work gives some well thought-out stories of how to apply biomimicry to cities which can easily be discussed with teams operating in cities," he says. "I am hoping that this new thinking will enable cities to explore and implement solutions which have the right insight to be effective."

The Biomimicry Guild is currently working on a concept called the Biomimicry Innovation Process, which can help take the process from this charrette point into conception and marketplace in the most sustainable way. Bringing business and biomimicry closer together will be due to the variety of participants in the Biomimicry Professional Certification program, an intensive biomimicry training program. The latest round of graduates in the two-year program included biologists, engineers, designers and even four people with business backgrounds and it is that kind of diversity and cross-disciplinary approach that will ensure that biomimicry will be embraced by various walks of life.

2.6 Psychology of Processing

It is crucial designers know how individuals process information. In order for an individual to understand a design solution resulting from the biomimetic design process, he/she needs to know the 'biomimetic' thinking behind the design. Otherwise, one may think that any biomimetic design is 'just a form mimicking a natural form;' which is superficial thinking. There needs to be an evaluation of the final design solution, as well as an evaluation of how humans consume, teach, live, spend, work, play, and design. Are people doing all of these things in the manner that is the most conducive to life here on this planet? How would nature assess society's daily habits? In applying the biomimetic mindset, it opens up the possibility to make the necessary changes to live sustainably.

In order to change one's mindset, perception, and/or outlook, one needs to expand the possibilities and one's creativity. This is the beauty of integrating biomimicry and nature's design principles within graphic design; coming up with ideas or solutions that one may have never stumbled upon otherwise. In order to expand one's creativity, he/she needs to affirm one's own individual creativity. Although many facets of human creativity are similar, they are never identical. All pine trees are very much alike, yet none is exactly the same as the other. This is the benefit of having BaDT, combining creative minds of all types and backgrounds to create a unique design solution.

Along with expanding possibilities and creativity, focus is also key. All too often we are bombarded with information; an information tidal wave of sorts. With minds processing techniques and abilities, we do not make the fullest use of our ability to see. We move through life looking at a tremendous quantity of information, objects, and scenes, and yet we *look* but do not *see*. However, before one starts looking for ideas, he/she needs to know what one is looking for and what his/her goal is. The important step to take next is to set the problem or design challenge down in writing. Since our attention is constantly shifting, one may become indecisive about what, if anything, he/she should focus on. Psychologists have demonstrated that people are able to keep only about five – nine pieces of information in his/her mind at a time. Therefore, keeping sketches and thoughts written

down related to one's projects is essential in order to 'bake' them into one's shared consciousness. As designers, we rely heavily on the possibility system. Moving ahead with our ideas and information we gathered to create hypotheses and visions. These give us the framework through which to look at things (nature) and also something to work towards (biomimetic design solution). Therefore, our perception is the most important part of our thinking...how we look at the world, what things we take into account and, ultimately, how we structure our world. Perception works as a self-organizing information system, just as within nature, building on the smaller parts and creating larger sub-systems. Such systems allow the sequence in which information arrives to set up patterns; these patterns being the environments in which we encounter and organize to create recognizable systems for processing information. There is a life-cycle with which we process. For example, the intended message is perceived and originated, a design is then encoded, and then relayed to the viewer as a presented design. Once the viewer examines the design and forms a perception, one interprets the design and determines if he/she was able to receive the intended message. As designers, it is pivotal we know this to understand how our viewer is perceiving our design solutions. The more we accept responsibility and dedicate ourselves to generating ideas found within nature, the higher the probability of reaching an innovative solution. Thinking is the ultimate human resource. The quality of our future will depend entirely on the quality of our thinking and of our mindset.

Section 3

Section 3 : 3.0 Process

Process, by definition, is a series of actions or steps taken in order to achieve a particular end; a natural or involuntary series of changes; or a systematic series of mechanized or chemical operations that are performed in order to produce or manufacture something. If designers wish to adopt the biomimetic + graphic design process, then they must see their profession as an integrated process and a problem-solving discipline. Successful graphic designers correctly define the context of their design, users and constraints. It is cross-disciplinary, allowing architects to learn from animal architecture, and graphic designers to learn from animal communication, biologists and life's principles. The process of collecting several organism examples helps to analyze the principles involved— if many different organisms use variations of a common strategy, then you know your approach is pretty promising. The entire process is a mix of intuitive and deliberate actions, resulting in brainstorming without censorship to create the final solution.

This graphic design + biomimetic process is born from new ideas, conceived from old ideals. It is taking nature's time-tested ideals over a period of approximately 3.8 billion years and introducing and integrating them with modern design practices. It is a synthesis of graphic design + biomimicry. The direct method, unlike that of the indirect method using abstracted principles of how nature designs, is exactly what it states: directly going out into the environment and seeking a natural system and organism; finding an example and defining the problem in its context, then finding the organisms with a similar problem and context to see what they do. The goal is to find many divergent organisms to see which has the best and most relevant strategy. Within this process, it is vital designers take into account their time and resource constraints, in order to optimize rather than maximize materials, so they can then appropriately assemble and implement the materials efficiently within their design solutions. This is the core of the biomimetic discipline.

The direct method is what you usually hear about— where the designer or engineer can point to an organism and say 'it's like that.' The value of this method is that even the most creative people still get stuck thinking along certain lines. In fact, a method called TRIZ, which has been developed to catalog and analyze problem-solving techniques, claims there are just 40 methods that people have ever used to think up new inventions. TRIZ is the (Russian) acronym for the 'Theory of Inventive Problem Solving.' G.S. Altshuller and his colleagues in the former USSR developed the method between 1946 and 1985. TRIZ is an international science of creativity that relies on the study of the patterns of problems and solutions, not on the spontaneous and intuitive creativity of individuals or groups.

Since evolution works differently from our brains, nature has used many more. Julian Vincent, author of *Structural Biomaterials*, at University of Bath has been working on extending TRIZ to biology, cataloging and analyzing the ways other organisms have 'invented' new solutions to problems. But so far the best way to find ideas in nature is to go look for yourself; arguably it always will be.

3.1 Thesis Parameters

After accumulating all of my research, I initially took some time to reflect back upon all that I gathered, trying to figure out the best way to organize all of the content in the simplest manner possible and making it comprehensible for my target audience. The content and scope of my thesis is quite large and can be broken up into several large 'chunks' of information. I decided that the easiest way to go about doing it would be to organize my final print application book into the six different sections/stages of my biomimetic design process: (1) Defining, (2) Analyzing, (3) Observing, (4) Selecting, (5) Implementing, and (6) Evaluating, denoting each section with a different research area of study. I also added two additional chapters before and after the process chapters: Beginning and Progressing. In doing this, it made the process that much more manageable.

3.1.1 Design Considerations, Process & Content

In coming up with my own biomimetic design process of integrating the methodologies of both graphic design + biomimicry, I began with looking at how the natural environment would begin the process in solving a design challenge. Defining the problem well is always a challenge in design, but then finding organisms that have relevant strategies is a trick in and of itself. Some examples are easy to find just by going for a walk and paying attention; other examples are more obscure, and require research— online, in books and academic journals, or even by hiring a biologist to consult (a BaDT). It is especially useful to find many examples from wildly divergent sources, like when looking for structures, do not just look at animal bones, but also insect exoskeletons, the branches of trees, or the stems of grasses so that you have design alternatives. Just because a certain strategy evolved in one place does not mean it is the best solution; the power of biomimicry is that you can find many different solutions that you have never thought of.

It is always a good thing to remember that good biomimetic design is inspiration from nature, not a slavish imitation of it. As Michael Pawlyn, an architect and advocate of biomimicry, states "If you look beyond the nice shapes in nature and understand the principles behind them, you can find some adaptations that can lead to new innovative solutions that are radically more resource efficient. It's the direction we need to take in the coming decades."

In essence, within the graphic design + biomimicry process, what is stressed is that the natural world is a cauldron of research and development, trial and error, where technologies that fail are called fossils and technologies that succeed survive to fight another day. Why reinvent the wheel, when nature has figured out how to slither, walk, hover and fly in so many different ways? Who can deny that nature got here first?

When looking at the visual process of biomimetic design, it can be shown in three different models: linear, circular, and branching. It is necessary to show the process in different forms to stress that it overlaps other frameworks and disciplines. The process of integrating the two differing methodologies is bringing nature's wisdom not just to the physical design, but also to the manufacturing process, the packaging, the shipping, distribution, and take-back decisions. We use the three different models to emphasize the reiterative nature of the process to make clear that it evolves in more pattern than one— after solving one challenge, then evaluating how well it meets life's principles, another challenge often arises, and the design process begins anew.

There are **6 Stages** within this new process:

1 Define
2 Analyze
3 Observe
4 Select
5 Implement
6 Evaluate

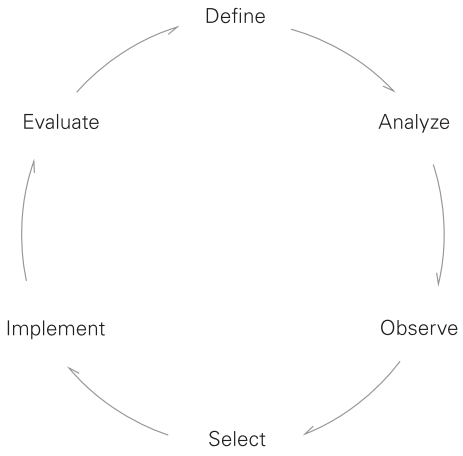
As previously mentioned, the visual process of biomimetic design can be shown in three different models: linear, circular, and branching. Since every person processes information differently based on his/her own experiences, showing more than one model of the process allows for a more thorough, cognitive understanding of the process and how it can be applied. The different models demonstrate how this biomimetic process overlaps with other frameworks and disciplines, emphasizing the reiterative nature of the process to make clear that it evolves in more pattern than one.

Linear Model

showing the linear and evolutionary process of nature and design

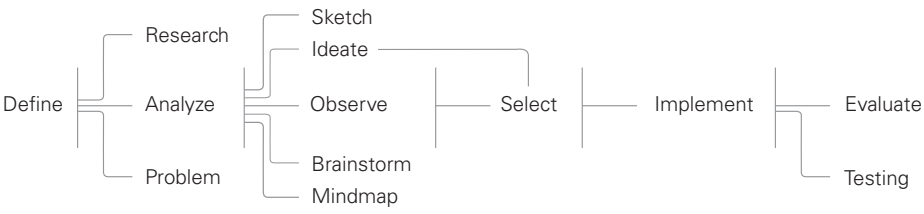
Circular Model

showing the reiterative nature of the process and continuation of the system within the feedback loop



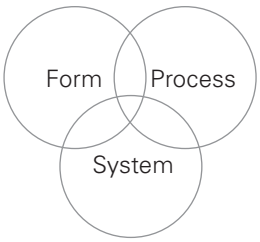
Branching Model

showing the branching nature of the process, visually connecting the smaller sub-areas with the six stages of the process



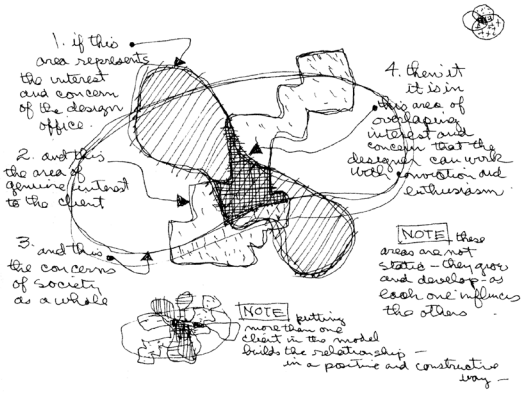
3 Lenses

There are also three different lenses through which you can evaluate and explore this biomimetic design process through: form, process and system. Carl Hastrich, a professor at OCAD University in Toronto and toy designer, describes looking at biomimicry as placing a heavy emphasis on the system as context, and broader inspiration into why an adaptation from an organism occurs. "Ecosystems are an emergent property of biological organisms and the environment, and in order to really understand it we need to look at the full context. The weakness of some investigations at a systems level occur when there is no deeper understanding of the biological mechanisms that occur for systemic relationships to form. Therefore it is inherently complex to research and a difficult story to tell."



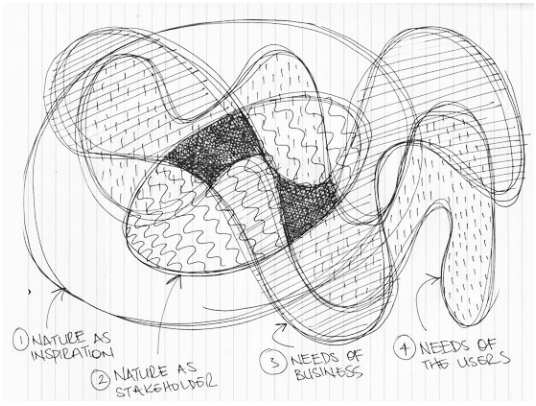
Below are other organic interpretation models showing design's role and value within society, as well as the reverse, exploring society's value to design. Carl Hastrich took Charles Eames 1968 diagram, explaining the design process as achieving a point where the needs and interests of the client, the designer, and society as a whole overlap, and re-designed it to fit his own mode of thinking regarding biomimicry and design.

1



Charles Eames, 1969, for the exhibition "What is Design" at the Musée des Arts décoratifs, Paris, France

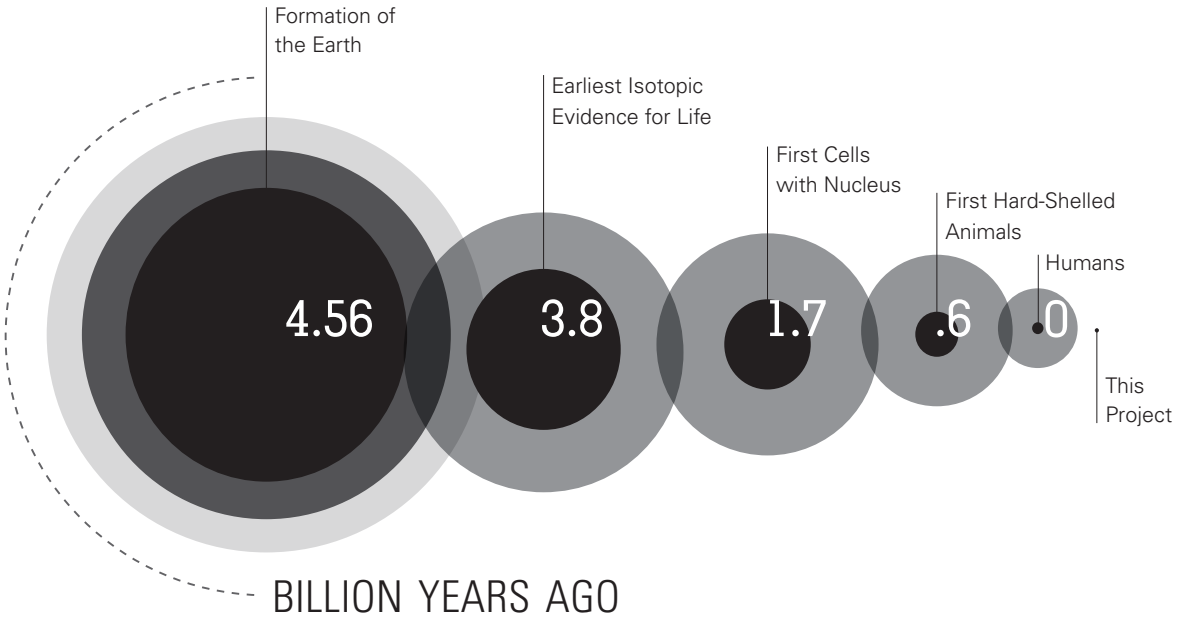
2



Humble Evolution of Charles Eames definition of Design; Carl Hastrich's attempt to define "Biomimicry Design" http://bouncingideas.wordpress.com/

This infographic was created to give an immediate visual of how animals and nature's design have been on this planet for over 3.8 billion years and in comparison we, humans, as a species have only been residing on this planet for little to no time at all. This aids the readers in truly understand and grasping the concept that we have not been here on this Earth very long at all and this is why we should be looking to nature to help solve the problems we are currently grappling with.

This is to be placed within the 'Beginning' section of the final print application book where the objective and scope of this project will be discussed.



After assessing both methodologies, it was critical to look at both side-by-side to see the commonalities, as well as the drastic differences. There are really two schools of design and thought to analyze and evaluate; the graphic design (technologic, human) side versus the biomimicry (biologic, nature) side. Looking at both natural and human technologies forces us to think about each in novel ways. For the graphic designer, a perceptive look at nature's technology can do just that: It can provide the wide-angle view that reveals possibilities that would otherwise escape consideration. Also, this view of nature as technology has provided an unusual perspective on the natural world around us. Recognizing that nature deals with the same variables as do human designers leads us to comparing both products and processes. The two sides and their technologies share the same planet, they experience the same pressures, temperatures, gravitational accelerations, winds, and water currents so why not examine them in this manner. It comes down to...what can we learn in doing this?

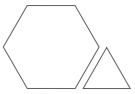
GRAPHIC DESIGN (Technologic, Humans)	VS	**BIOMIMICRY** (Biologic, Nature)
Designers create something that does not exist		Biologists study something that exists: nature, in all its splendor
Human technology springs from what is variously called invention, discovery, development or planning		Nature's process is that mechanism Darwin uncovered, evolution by natural selection
Graphic Designers can borrow devices from other designers and history		Nature must follow an inherited plan set by genetic code and evolution
Humans have a great affinity for flatness		Nature makes very few flat surfaces
Designers love the mechanical and geometrical shapes, using right corners in abundance		Nature, on the other hand, uses very few right angles, if any, using curves and gradual gradients
Designers, and people, like to create by taking something and manipulating it into something else, taking away and adding, then disposing what was not used		Nature, however, would cut something into pieces and reassemble them from the ground up, building by lacing them together; optimizing the material with little to no waste to dispose of
Overly productive, using brute force resulting in excess, waste and pollution		Highly protective, using finesse resulting in conserving and nurturing
What can our technologies provide?		What do we *need*? How can nature provide?

It has been proven that people remember tidbits of information better when it is represented visually with an icon or symbol set. So, I created 14 icons using a hexagon polygon inspired by the honeycomb shape of the bee cell and its triangular counter-part to visually represent each design principle of nature.

This informational chart will be placed at the end of the section after the principles are introduced.

14 Design Principles of Nature

1
Self-Assembly from the Ground Up

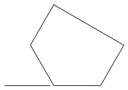


5
Respect Diversity

9
Use Life-Friendly Chemistry

13
Foster Cooperative Relationships

2
Waste = Food



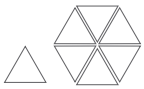
6
Self-Appropriate Technologies

10
Organize Fractally

14
Don't Foul your Nest

3
Evolve Solutions, Don't Plan Them

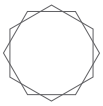
7
Be Resourceful



11
The System > the Sum of Its Parts

4
Adapt to Changing Conditions

8
Optimize Rather than Maximize



12
Leveraging Interdependence

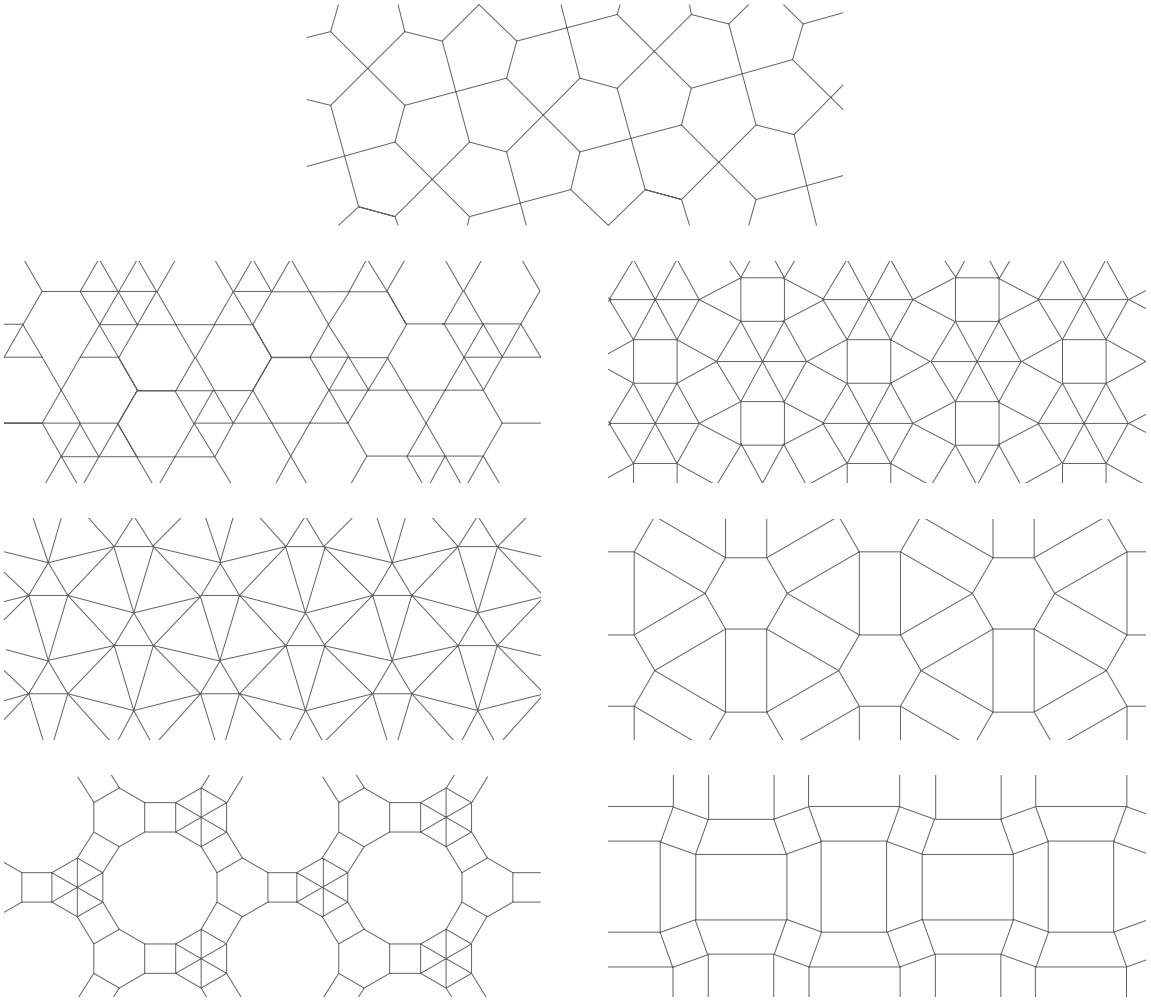
Below is another informational chart to help demonstrate the synthesis and combination of the 14 Universal Graphic Design Principles + 14 Design Principles of Nature, which help to form the Indirect Method of the biomimetic design process, theory and system.

This informational chart will be placed at the end of the section after the principles are introduced.

	Universal Design Principles	Design Principles of Nature
	Form Follows Function	Be Resourceful
	Mimicry	Adapt to Changing Conditions
	Self-Similarity	Organize Fractally
	Symmetry	Use Life-Friendly Chemistry
	Uniform Connectedness	The System > the Sum of its Parts
	Convergence	Foster Cooperative Relationships
	Feedback Loop	Leveraging Interdependence
	Hick's Law	Waste = Food
	Hierarchy of Needs	Self-Assembly from the Ground Up
	Life Cycle	Evolve Solutions, Don't Plan Them
	Depth of Processing	Self-Appropriate Technologies
	Five Hat Racks	Optimize Rather than Maximize
	Mental Model	Respect Diversity
	Ockham's Razor	Don't Foul your Nest

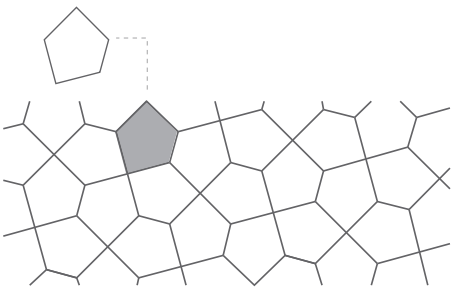
These tessellation patterns are designed and inspired by surface mimicry, animal camouflage, fractal patterning, the Sierpinski triangle and natural algorithms. By creating actual patterns using the algorithms and tessellation patterning system, it will show readers how to apply the process to create unique pattern designs.

The seven patterns will be placed within the 'Observing' chapter of my book dealing with camouflage and the surface mimicry of animals.

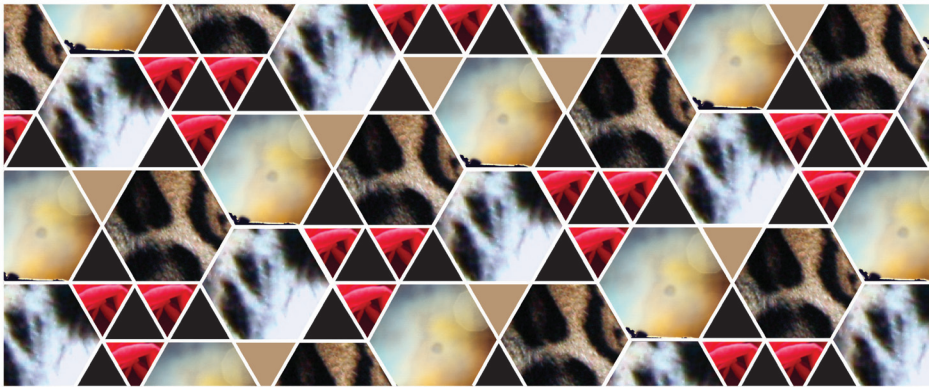


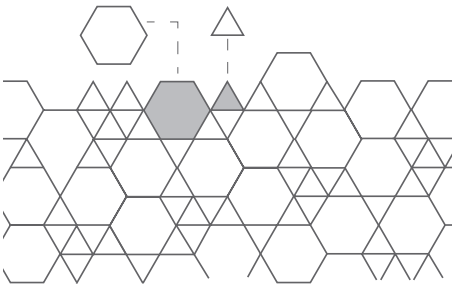
To make these unique pattern designs, the biomimetic design process was used. The first stage began with defining the problem: What would Nature do? How would nature create these specific patterns and in what context? How would it utilize form within function? After asking these questions and going through the appropriate stages of defining, analyzing, and observing, the selection of which animals to emulate was the next step. The animal skins and camouflaging/surface mimicry techniques that were chosen were the giraffe, leopard, chameleon, iguana, tortoise, monarch butterfly, and cephalopod (Blue-ringed Octopus). After the animals were chosen, the implementation stage of the process could now begin, which is where images of the same hue and mimicry patterns were chosen to be repeatedly placed beneath each polygon. The images seen looking through each polygon act as a window, showing various color hues, changes and patterns similar to those seen on the animal's transformed-camouflaged skin. In evaluating the designs, it is apparent that by using the tessellation and fractal techniques was successful in creating individual grid-like patterns. The functioning aspect is in the form of deception to emulate the animal and disguise the form by creating shapes for specific pattern purposes. What is shown for each graphical solution is the final pattern design, the underlying mathematical and geometric grid system, as well as the natural inspiration and surface mimicry of the specific animal.

Regular Tessellation Pattern using the same pentagonal shape throughout | Giraffe

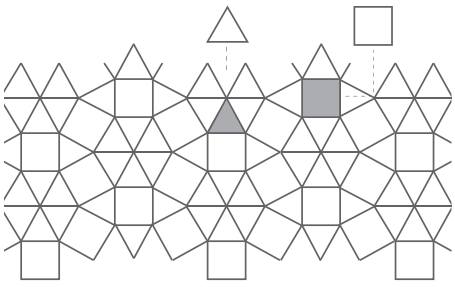


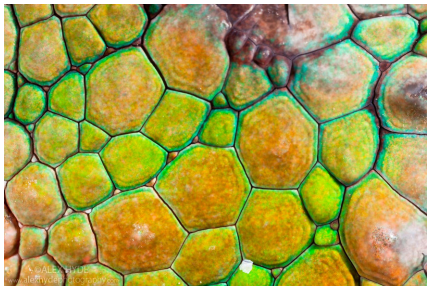
Semi-Regular Non-Uniform Periodic Pattern using 2 polygonal shapes: hexagon and triangle | Leopard



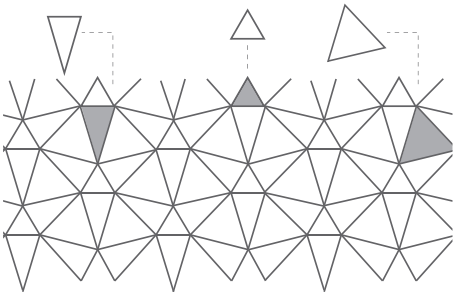


Semi-Regular Non-Uniform Non-Periodic Pattern using 2 polygonal shapes: triangle and square | Chameleon

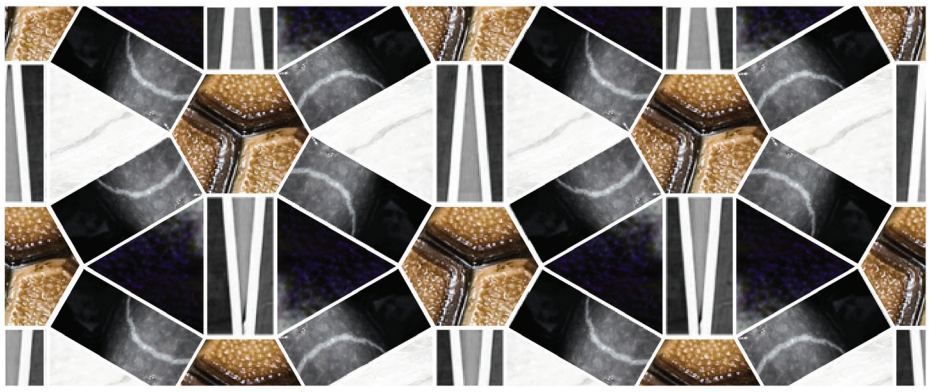


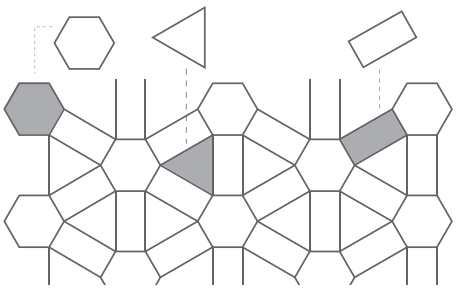


Regular Uniform Non-Periodic Pattern using the same triangular shape throughout at differing sizes | Iguana

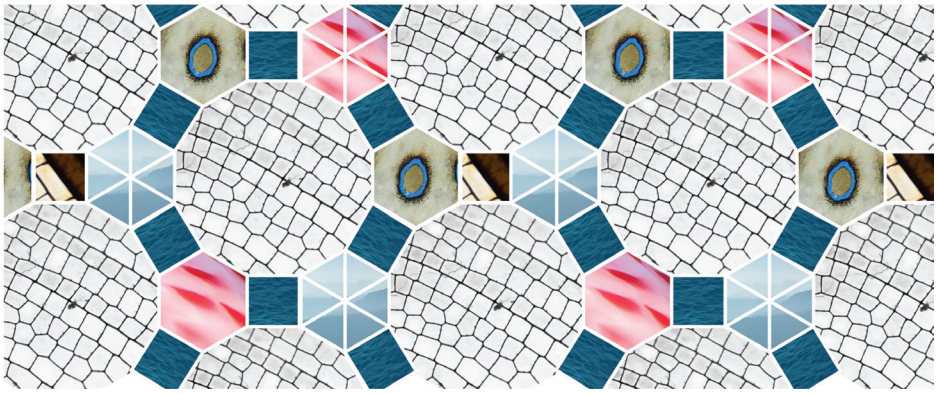


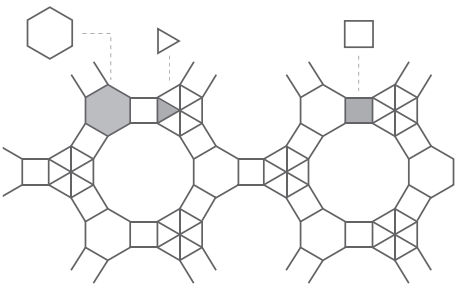
Semi-Regular Non-Uniform Non-Periodic Pattern using 3 polygonal shapes: hexagon, triangle and rectangle | Tortoise



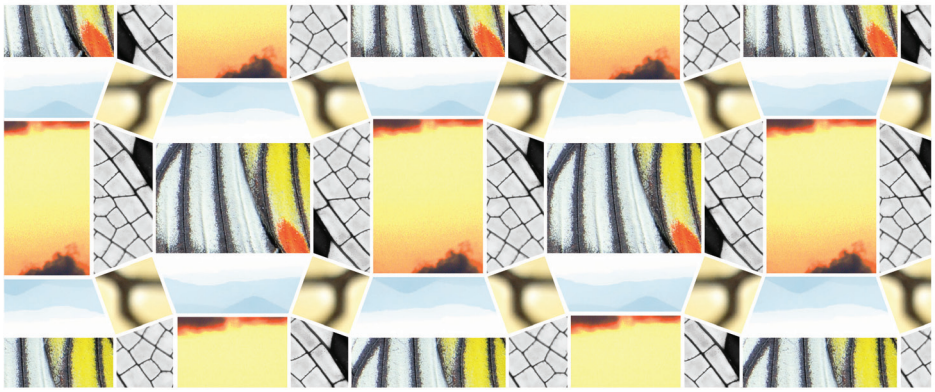


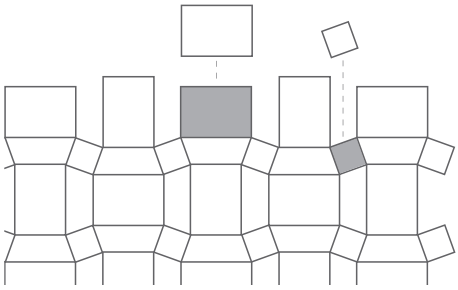
Semi-Regular Non-Uniform Periodic Pattern using 3 polygonal shapes: hexagon, triangle and square | Cephalopod





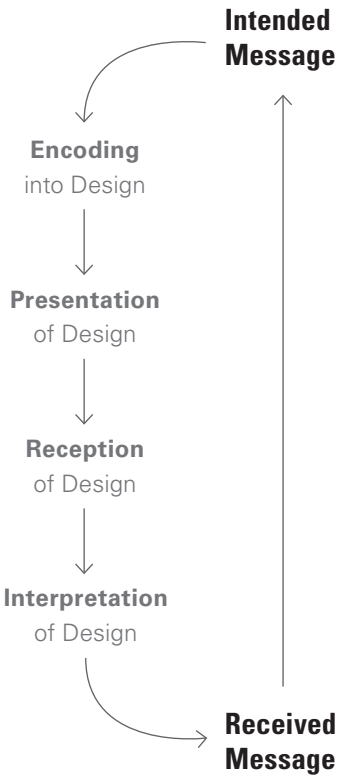
Regular Uniform Non-Periodic Pattern using the same rectangular/square shape throughout | Monarch Butterfly





There is a life-cycle with which we process information. As designers, it is pivotal we know this to understand how our viewer is perceiving our design solutions. The more we accept responsibility and dedicate ourselves to generating ideas found within nature, the higher the probability of reaching an innovative solution. Thinking is the ultimate human resource. In order to visually demonstrate in a simple way, an informational/directional diagram was made to show the different stages in which we process.

This informational diagram will be placed at the end of the 'Evaluating' section once the psychology of processing is discussed.



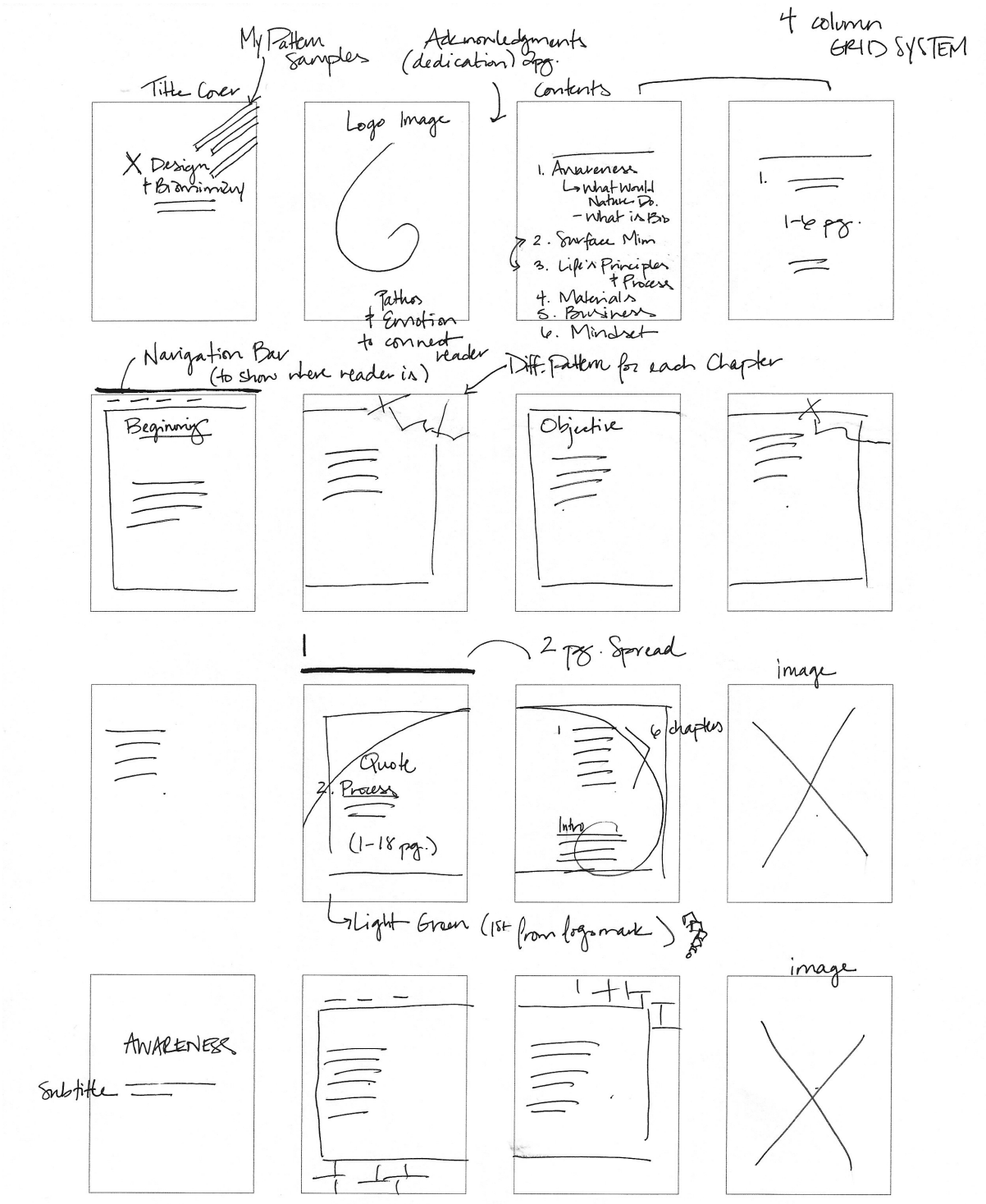
Design Parameters for the Final Print Application

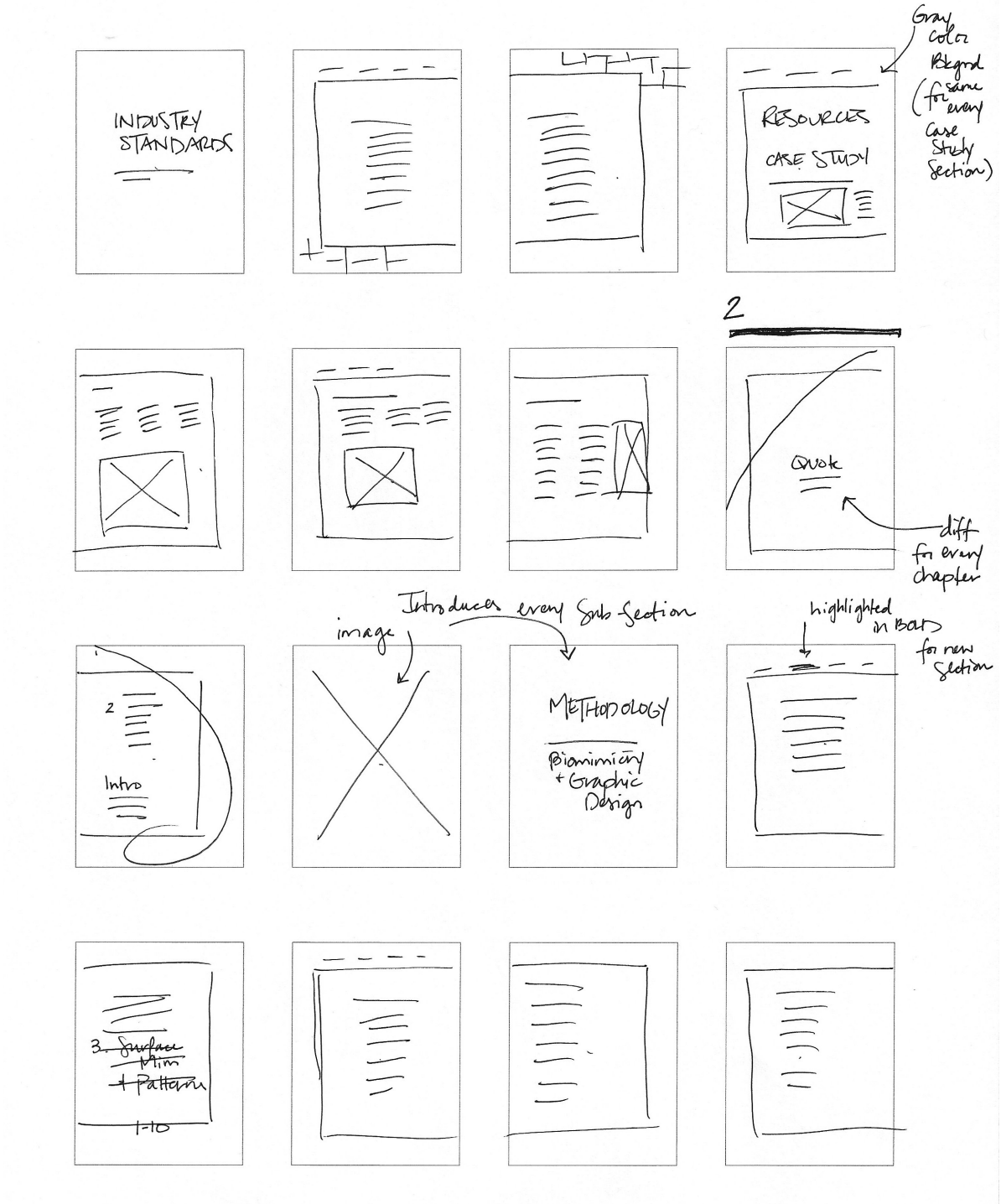
Printer	Blurb, http://www.blurb.com/
Dimensions	• 1 Book • Standard Landscape (10in x 8in) • Hardcover • 160 pages
Typefaces	Univers LT Std Light, Bold, Condensed, Bold Condensed Memphis LT Std Medium
Point Size	Main Heading: 60 pt Sub Heading: 20 pt Body Copy: 9 pt

3.1.2 Pacing of Sections & Ideation

The sketching and ideation part of this process was very important and the majority of the time was spent on figuring out the specific layout and grid system that was going to be utilized. To figure out the pacing of each section and the specific content for each section, initial ideation sketches were done to ensure that all ideas were tried before implementation. To come up with a cohesive system, small thumbnails were sketched to try come up with different ideas for the opening section and sub-section pages, as well as the pacing of each section and how many pages were necessary for the final book.

A four-column grid system was chosen based on a trial and error method and the amount of information versus the space allotted (10in x 8in). This allowed for variety within the pages. Each chapter and main body of text are aligned the same with the exception of the 'Case Studies' and 'Resources' pages where the text was broken up into smaller and more digestible pieces of information to allow for diversity within the user experience. (This was implemented and decided after usability testing in which the idea was recommended several times).


4 column GRID SYSTEM
My Pattern Samples
Acknowledgments (dedication) 2pg.
Title Cover
X Design + Brainstorm
Logo Image
Pathos + Emotion to connect reader
Contents
1. Awareness
↳ what would Nature Do.
- What is Bio
2. Surface Mim
3. Life's Principles + Process
4. Materials
5. Business
6. Mindset
1.
1-6 pg.
Navigation Bar (to show where reader is)
Diff. Pattern for each Chapter
Beginning
Objective
2 pg. Spread
image
1
6 chapters
Quote
2. Process
(1-18 pg.)
Intro
↳ Light Green (1st from logomark)
image
AWARENESS
Subtitle


INDUSTRY STANDARDS
RESOURCES
CASE STUDY
Gray color Bkgrd (for same for every Case Study Section)
2
Quote
diff for every chapter
Introduces every Sub-Section
image
highlighted in Bar for new Section
1
2
Intro
METHODOLOGY
Biomimicry + Graphic Design
3. Surface Trim + Pattern
1-10

3.1.3 Color Choices

Subtle and natural tones found within nature were the final design decisions in terms of the color choices in the book. They were also inspired by lighter hues seen in the identity mark and used multiple times throughout the graphical design applications as well.

Each of the six sections/chapters of the book will have a different color background to differentiate it from the others

1

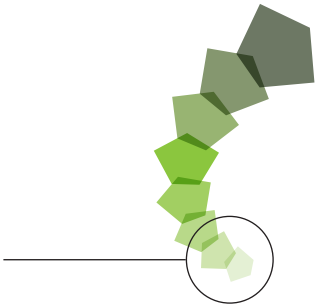
2

3

4

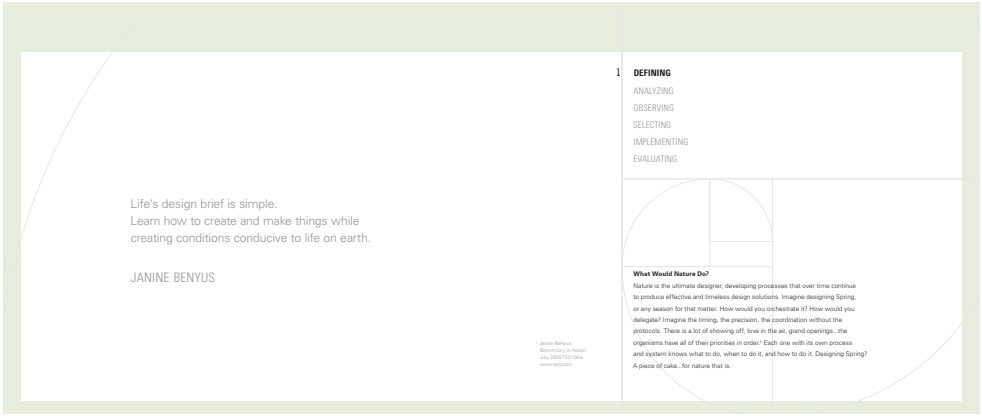
5

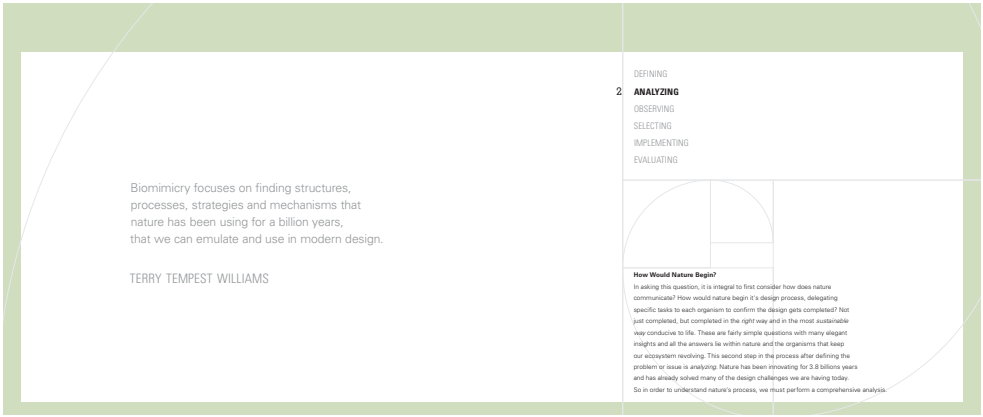
6

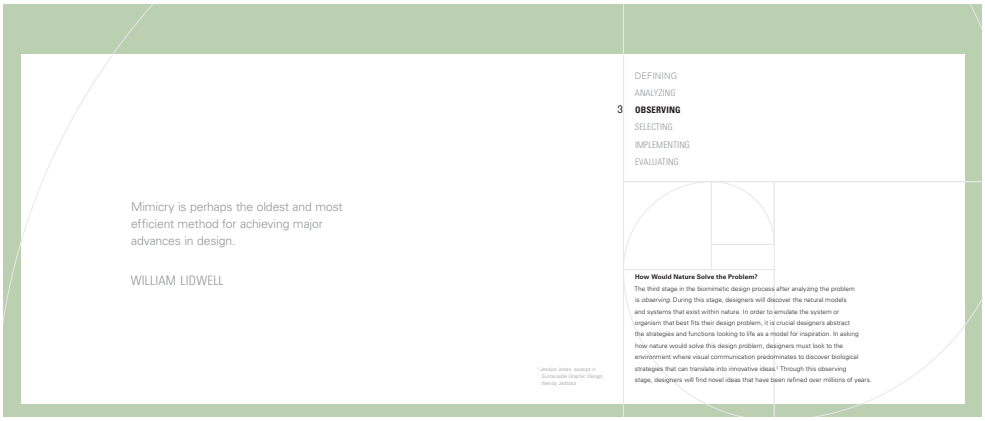


3.1.4 Design Concepts

The beginning of each chapter will have the same layout with a quote on the left page and navigation bar of chapters on the right following the introduction on the bottom of right page. The Golden Section is also seen to show the underlying grid pattern.



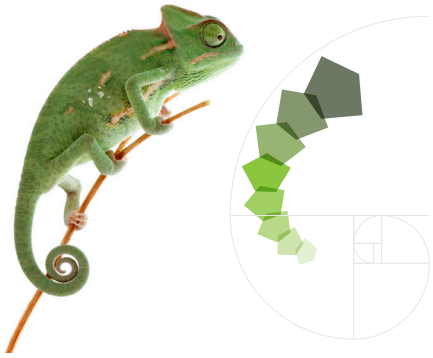




The beginning of each sub-section will have the same layout with an image on the left page and heading and sub-heading on right

INDUSTRY STANDARDS

Modern Design Practices



METHODOLOGY

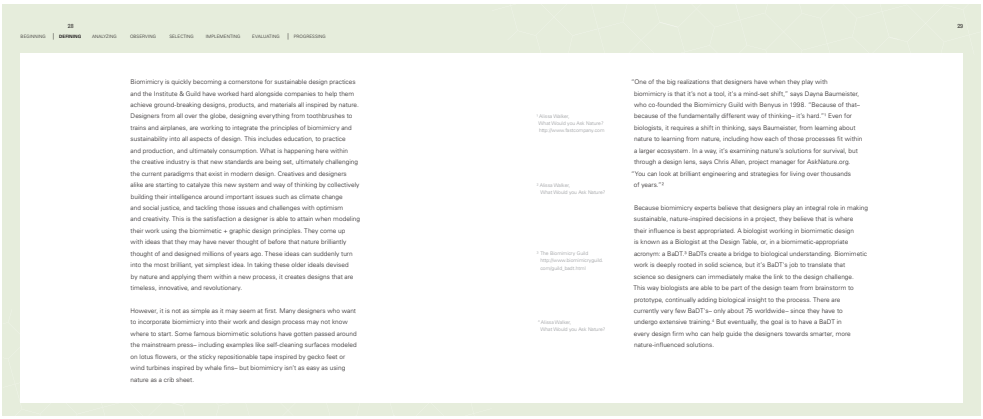
Biomimicry + Graphic Design

SYSTEM SOLUTION

Ethos, Reconnect

Each chapter will have a navigation bar on the top left of the page to signify to the reader where they are. Also, each chapter will have a different tessellation pattern featured on the top right and bottom left of the pages. Footnotes will always be to the direct left of text.

Navigation Bar



Different Pattern Designs

Footnotes

3.2 Usability Testing & Considerations

People of varying design backgrounds, education and disciplines will be reading this book. Therefore, it was necessary to make sure that all areas of the target audience were covered. When writing this book, it was obvious that all users would need to be addressed and a basic level of knowledge and understanding of both graphic design and biomimicry would need to be written in order for any specific user to comprehend the terminology and information presented within the book.

It is also important to note that although this guidebook is rich in text and information, graphics and photographs are also present to help visually communicate certain sections, principles, and processes. Guidebooks that are weighted too heavily in one direction or the other (textually or visually) could potentially drive away users who feel that they do not want to take the time to read all of the information or feel that they are not receiving the proper type of level of information appropriate in order for them to understand the content. It is key to make all information accessible to anyone who might be reading this book and to include diversity in the way that it is all portrayed.

3.2.1 Physical Considerations

It was important to consider the pragmatic elements such as book size, format, binding, and page material. Below is a short list of some pragmatic and physical considerations that will help shape the type of experience the users will have.

Size

Landscape format - easier for users to hold, traditional layout for photographs

Large 8 x 10 - similar to a sheet of paper, will feel comfortable in the user's hands

Binding

Hardcover - easier for the user to hold on to

Dust Jacket - can also act as a book mark for users to hold their place

Paper

Thicker paper - easier for the user's to grab and turn pages

Coated vs. Uncoated - spill proof

Images

Should there be a combination of photographs, icons, and infographics? - Yes

Should each section and sub-section have a different photograph? - Yes, yet maintain the same look and feel

Should the photographs take up the entire sheet of the paper or only a smal portion? - Entire sheet of paper

Image Quality - similar content, style, and complexity

Order

Is there a specific order for the book? - Yes

What is the organization within each chapter or section? - Each chapter will be one of the six stages

How will the chapters be differentiated? - By color and pattern design on every page

3.2.2 Selection of Information

Resource guidebooks usually include a series of steps or stages to follow in order to produce a final solution. In order for the guidebook to make sense and follow a sequential order, each section will be a different step in the biomimetic design process: (1) Defining, (2) Analyzing, (3) Observing, (4) Selecting, (5) Implementing, (6) Evaluating. Within each of these sections, other types of information will be dispensed like the definition and history of biomimicry, cross-disciplinary design tables, icon charts of the fourteen design principles of nature, a synthesis and comparison of nature's design principles with the universal design principles, and charts and diagrams explaining the significance of the biomimetic design process. Below is the entire content list of elements that will be included in the final print application.

Beginning

Introduction - Situation Analysis

Objective - Scope of Project

1 **Defining**

Introduction - What Would Nature Do?

Awareness - Innovators at the Institute

Industry Standards - Modern Design Practices

2 **Analyzing**

Introduction - How Would Nature Begin?

Methodology - Biomimicry + Graphic Design

Meme - Nature's Design Principles, Indirect Method

Graphic Design - Universal Principles & Elements

Process - Integrating the Disciplines, Direct Method

System Solution - Ethos, Reconnect

3 **Observing**

Introduction - How Would Nature Solve the Problem?

Patterns & Surface Mimicry - Animal Camouflage

Fractals & the Sierpinski Triangle - Natural Algorithms

Graphical Solutions - Tessellation Patterns

4 **Selecting**

Introduction - What Tools Would Nature Use?

Life-Friendly Materials - Reducing our Carbon Footprint

5 **Implementing**

Introduction - How Would Nature Delegate?

Biomimicry + Corporations - Network & Facilitate

Creative Sessions - Cross-Disciplinary Design Tables

6 **Evaluating**

Introduction - How Would Nature Assess?

The Biomimetic Mind-set - Psychology of Processing

Progressing

Onward - The Future of Biomimetic Design

Bibliography

Credits

3.2.3 User Survey

In order to more fully understand the opinions and thoughts from a more general point of view, I compiled a survey whose main goals were to determine what aspect of the book was the easiest to grasp and understand, what needs improvement, and the users' overall reaction of the book. Below is a list of sample questions that were included in my survey.

Initial Information

- Gender?
- Age?

Design Skills

- Are you a Designer? (Yes/No)
- **If yes,** What level designer would you consider yourself? (Beginner/Intermediate/Advanced)

- Did you go to school for design (or are currently enrolled)? (Yes/No)
- If so, what degree do you have (and/or on track of obtaining)? (Bachelor BFA/Masters MFA)

- **If no,** Would you still consider yourself somewhat knowledgeable of the basic principles and elements of design? (Yes/No)
- Do you think you would be able to critique a design piece? (Yes/No)

Knowledge of Biomimicry

- Do you know what biomimicry is? (Yes/No)
- Are you aware of the Biomimicry Institute or Guild? (Yes/No)
- **If yes,** do you have any personal experience working within the field (specifically design related)? (Yes/No)

Resource Guidebook Success Determinants

After reading or looking through the Graphic Design + Biomimicry book, were you able to understand and grasp the following concepts:

- What biomimicry is
- How to apply the six stages of the process to a real-world design scenario
- How to integrate biomimetic design into corporations and creative sessions
- How to take Nature's 14 Design principles and apply them to your process
- How the methodologies of graphic design + biomimicry integrate to form this process
- How the Sierpinski triangle and fractal patterns are applied to the process
- How to use natural algorithms to create tessellation patterns
- What materials and tools you should use in biomimetic design
- How nature can play a positive role nature within modern design practices
- Did the icons, charts, infographics, and diagrams help?
- Did you find the resources and case studies to be useful?
- Were the two system solutions helpful and necessary?
- Do you think the Graphic Design + Biomimicry Resource Guidebook is successful?
- Was the overall design of the book appropriate and aesthetically pleasing?
- Did the design and layout of the book make it easier to comprehend?

Please list any improvements that could be made:

Comments Overall:

3.2.4 Survey Responses and Results

Based on the collective answers I received from my user survey, certain themes and common answers were observed. Below is a concise list of some common user comments and responses:

Please list any improvements that could be made:

- Minor spelling and grammatical errors
- Darken the tessellation patterns that are featured on each page within each section

Comments Overall:

- Professional looking
- Good design
- Easy to comprehend
- Successful
- Good use of resources and case studies
- Consistent layout

After studying the survey responses, I made the appropriate changes to the final draft of my print application and was able to move forward with the editing and printing of my book.

Section 4

Section 4 : 4.0 Final Application

4.1 Application Versions

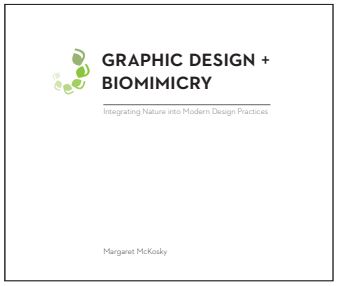
4.1.1 Print Application: Version 1

Page Dimensions

8 x 10 inches

Cover

- Typeface: Neutraface Demi
- Existing identity mark at the time

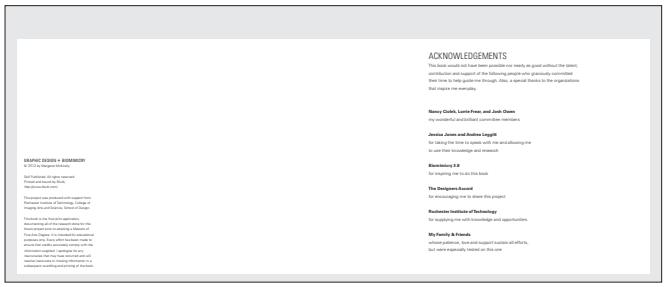


Inside Pages

- Typeface: Neutraface Demi
  Neutraface Light
- Margins
  T: 1p6 I: 3p9
  B: 1p6 O: 1p6

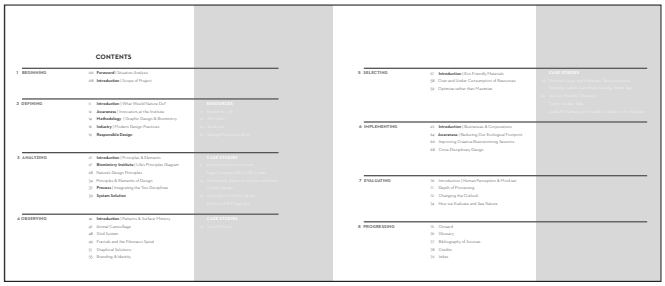
pg 3 - 4

- Typeface: Neutraface Demi
  Univers LT Std Light



pg 5 - 6

- Typeface: Neutraface Demi
  Neutraface Light
- Contents Page with proposed sections, sub-sections, resources and case studies

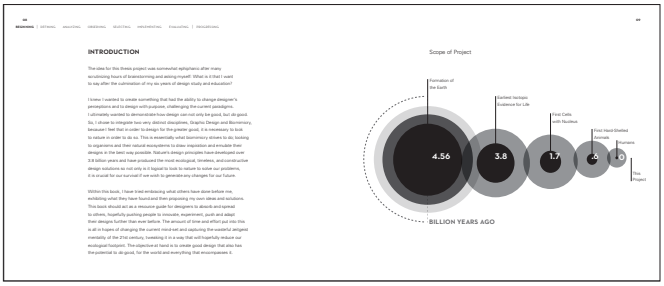


pg 6 - 7

- Typeface: Neutraface Demi
  Neutraface Light
  Univers LT Std Light
- Section titles appear above text
- Navigation bar at the top with pg no.

pg 8 - 9

- Typeface: Neutraface Demi
  Neutraface Light
  Univers LT Std Light
- Section titles appear above text
- Navigation bar at the top with pg no.
- Earth Infographic of scope of project



pg 10 - 11

- Typeface: Neutraface Demi
  Neutraface Light
  Univers LT Std Light
  Univers LT Std Bold
- New chapter/section layout
- Quote on left, chapter bar on right with introduction paragraph
- Use part of the logo as a signifier

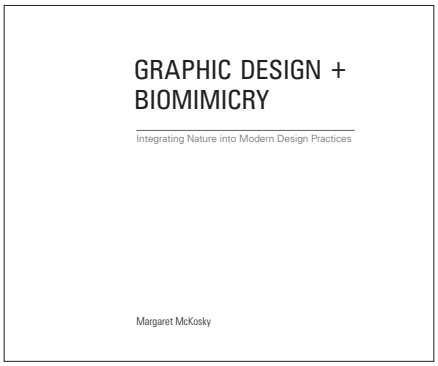
4.1.2 Print Application: Version 2

Page Dimensions

8 x 10 inches

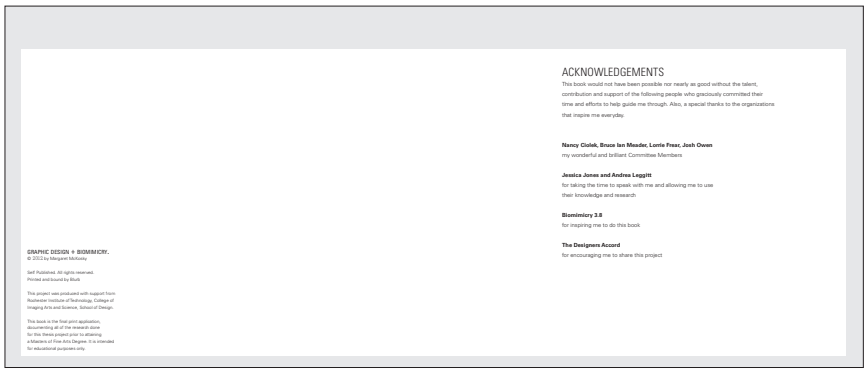
Cover

- Different Typeface is introduced: Univers Condensed
- Got rid of Neutraface all together



Inside Pages

- Univers Condensed
- Univers Light
- Different placement of copyright information



pg 4 - 5

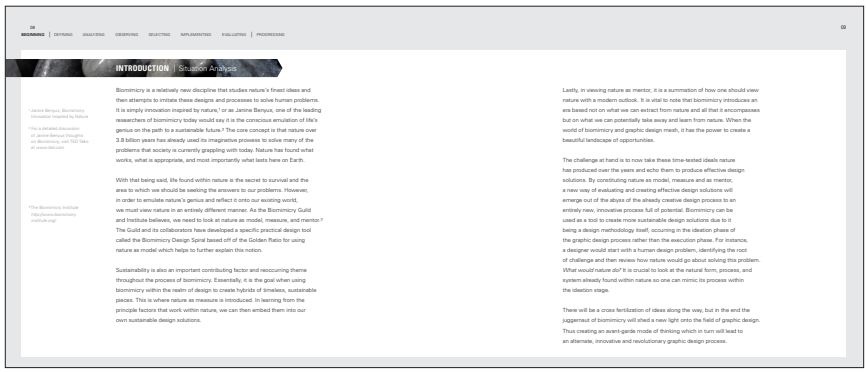
- Univers Condensed
- Univers Light

pg 6 - 7

- Introduction of color hues and hexagon icon
- Tessellation pattern is shown on the far right of both pages

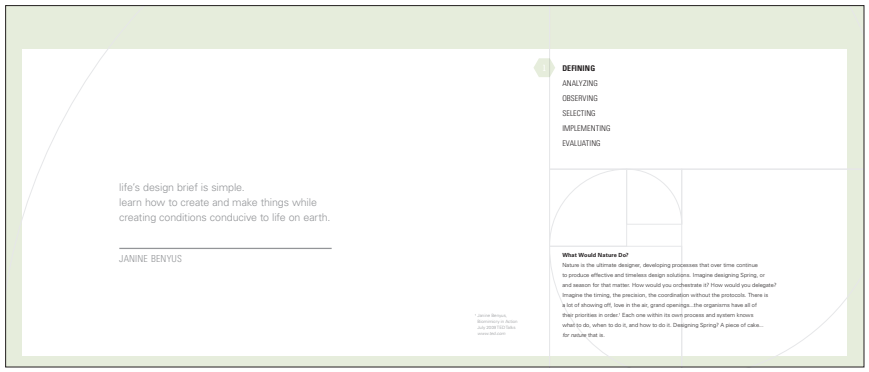
pg 8 - 9

- Dragged hexagon shape highlighting the sub-section title
- Acts as a 'peep hole' or window revealing an image underneath



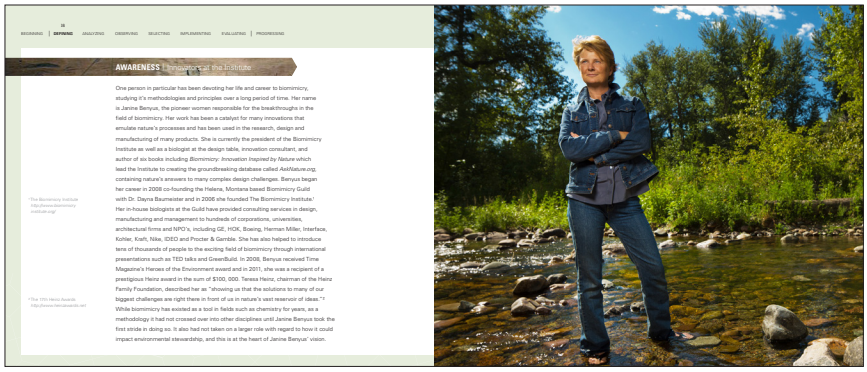
Section Page

- 1st color hue is used
- Hexagon icon now acts as the signifier



1st Section

- A tessellation pattern is seen on the bottom left and top right
- A different image is now highlighting the sub-section title
- A large image takes up the entire right page

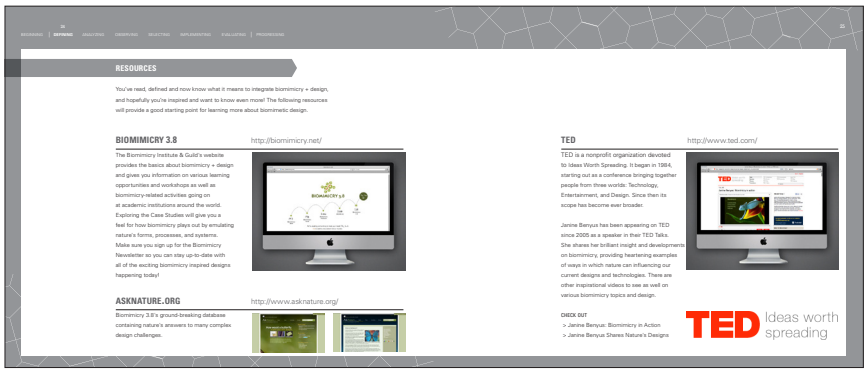


pg 18 - 19

- A second infographic is introduced but it is not working
- Smaller hexagon icons highlight the listed, bulleted numbers

Resource Page

- Gray color is introduced
- Has the same pattern design on the bottom left and top right
- No image is seen behind the sub-section title

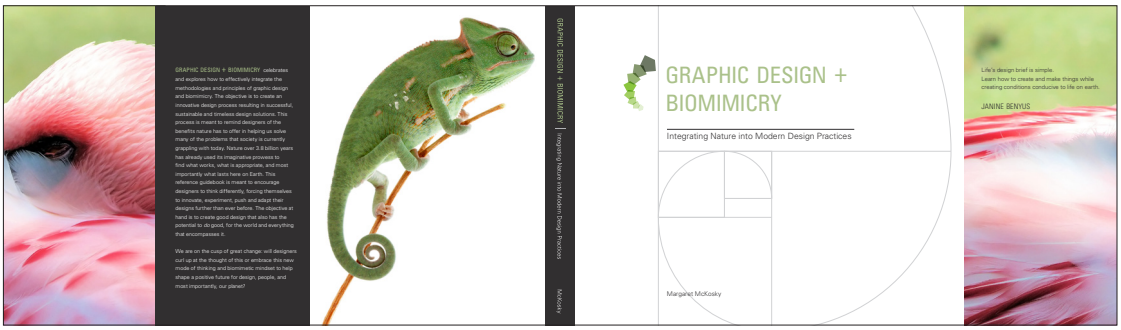


4.2 Final Print Application

Page Dimensions

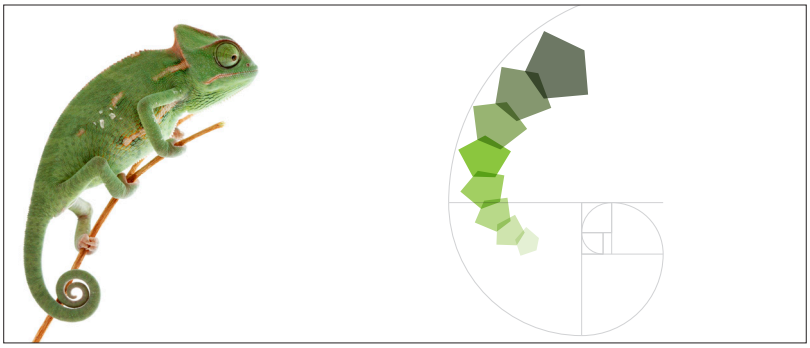
8 x 10 inches

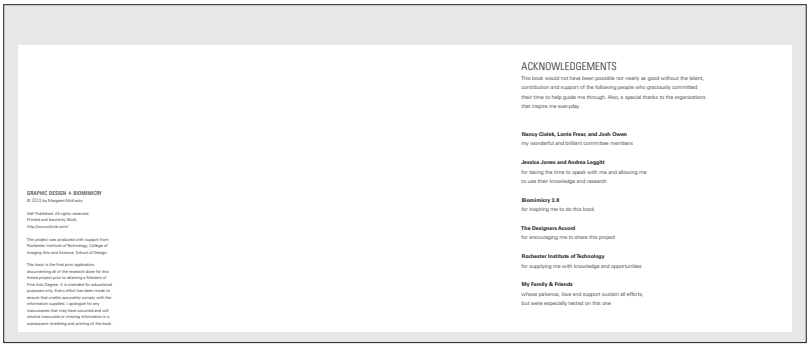
Front and Back Cover



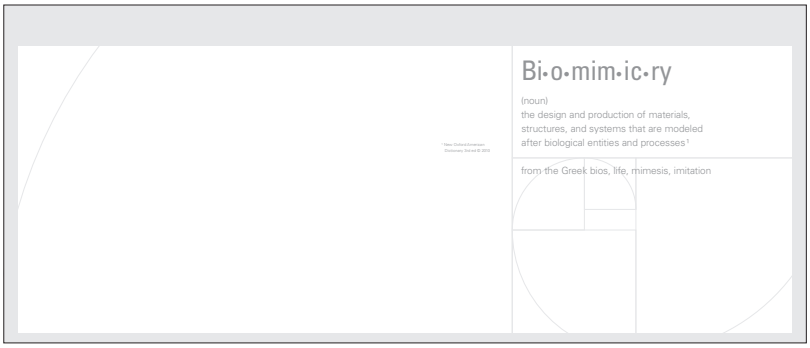
Inside Pages

- Shows the biomimicry side + the graphic design side of the thesis
- Acts as a nice opening and introduction of the book showing the inspiration behind the identity mark



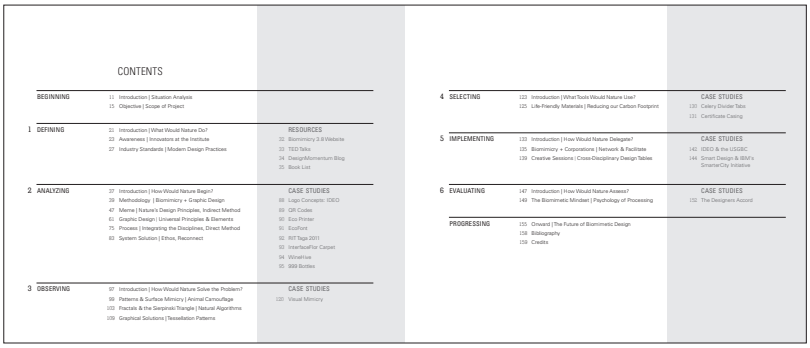


pg 6 - 7



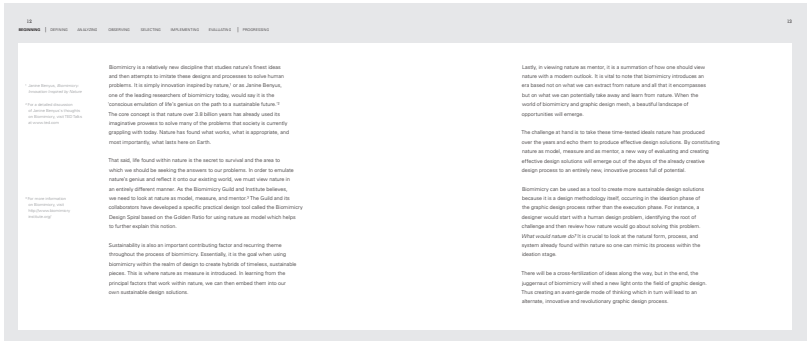
pg 8 - 9

- Took away the unnecessary hexagon icons highlighting the section numbers and pattern designs allowing for a simple, clean design (employing the Ockham's Razor design principle of maintaining simplicity)



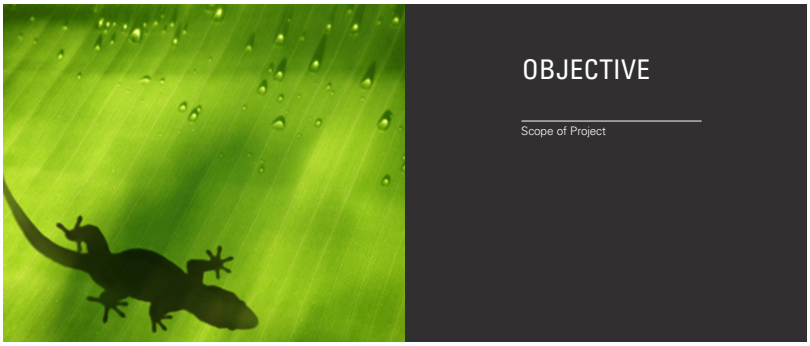
pg 10 - 11

- Each Sub-Section will have this same layout with a large photograph taking up the left page and the title and sub-title on the right with a clean horizontal rule to separate the two from each other
- Only the 'Beginning' and 'Progressing' Sections will have white title pages, the rest will have a dark-grey black background

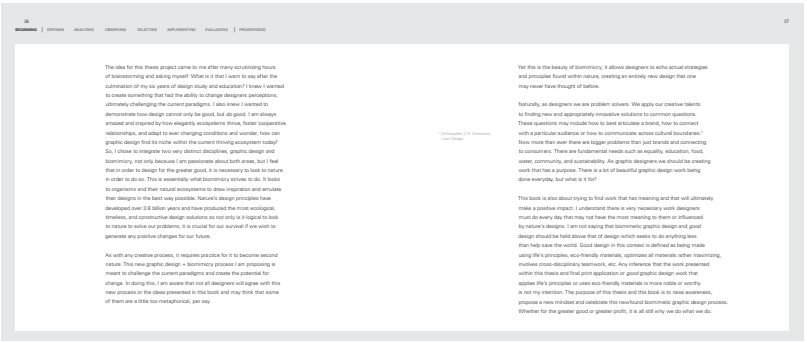


pg 14 - 15

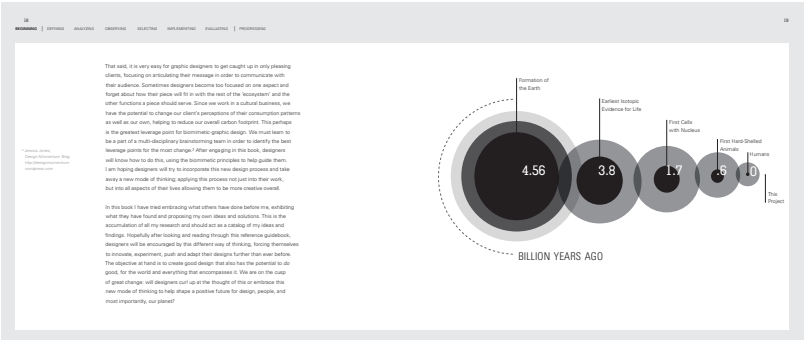
- This is the first sub-section layout with a dark grey-black title page/different image
- This allows for the user to take a breath during each section before more text is introduced



pg 16 - 17

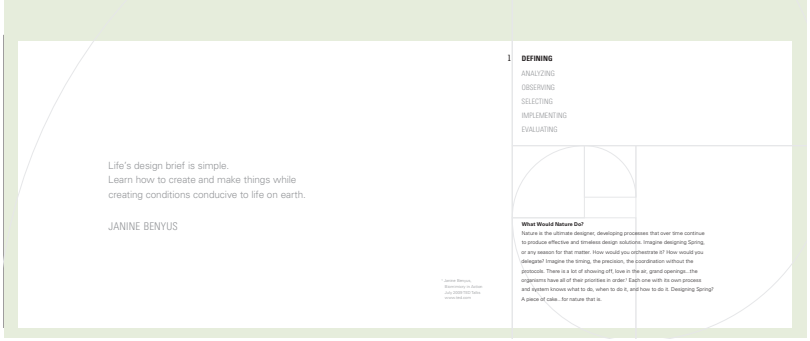


pg 18 - 19



pg 20 - 21

- Each section page will have this same layout
- The hexagon icon was removed from the number to allow for a cleaner and simpler design solution

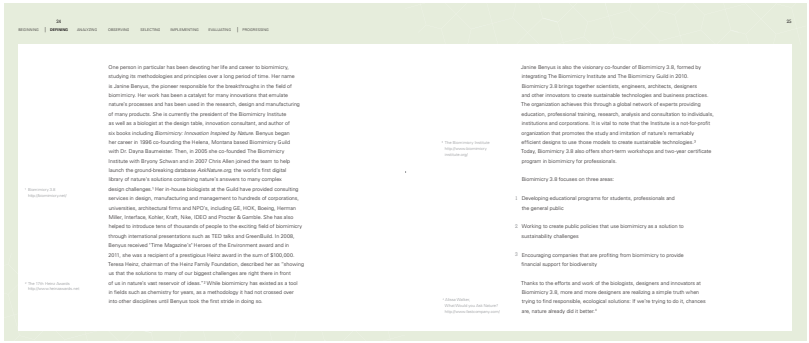


pg 22 - 23

AWARENESS

Innovators at the Institute

pg 24 - 25



14

BIOMIMING | DEFINING | ANALYZING | OBSERVING | SELECTING | IMPLEMENTING | EVALUATING | PROGRESSING

15

One person in particular has been devoting her life and career to biomimicry, studying its methodologies and principles over a long period of time. Her name is Janine Benyus, the pioneer responsible for the breakthroughs in the field of biomimicry. Her work has been a catalyst for many innovations that emulate nature's processes and has been used in the research, design and manufacturing of many products. She is currently the president of the Biomimicry Institute as well as a biologist at the design table, innovation consultant, and author of six books including *Biomimicry: Innovation Inspired by Nature*. Benyus began her career in 1996 co-founding the Helena, Montana based Biomimicry Guild with Dr. Dayna Baumeister. Then, in 2005 she co-founded The Biomimicry Institute with Bryony Schwan and in 2007 Chris Allen joined the team to help launch the ground-breaking database AskNature.org, the world's first digital library of nature's solutions containing nature's answers to many complex design challenges.[1] Her in-house biologists at the Guild have provided consulting services in design, manufacturing and management to hundreds of corporations, universities, architectural firms and NPO's, including GE, HOK, Boeing, Herman Miller, Interface, Kohler, Kraft, Nike, IDEO and Procter & Gamble. She has also helped to introduce tens of thousands of people to the exciting field of biomimicry through international presentations such as TED talks and GreenBuild. In 2008, Benyus received "Time Magazine's" Heroes of the Environment award and in 2011, she was a recipient of a prestigious Heinz award in the sum of $100,000. Teresa Heinz, chairman of the Heinz Family Foundation, described her as "showing us that the solutions to many of our biggest challenges are right there in front of us in nature's vast reservoir of ideas."[2] While biomimicry has existed as a tool in fields such as chemistry for years, as a methodology it had not crossed over into other disciplines until Benyus took the first stride in doing so.

Janine Benyus is also the visionary co-founder of Biomimicry 3.8, formed by integrating The Biomimicry Institute and The Biomimicry Guild in 2010. Biomimicry 3.8 brings together scientists, engineers, architects, designers and other innovators to create sustainable technologies and business practices. The organization achieves this through a global network of experts providing education, professional training, research, analysis and consultation to individuals, institutions and corporations. It is vital to note that the Institute is a not-for-profit organization that promotes the study and imitation of nature's remarkably efficient designs to use those models to create sustainable technologies.[3] Today, Biomimicry 3.8 also offers short-term workshops and two-year certificate program in biomimicry for professionals.

Biomimicry 3.8 focuses on three areas:

1. Developing educational programs for students, professionals and the general public
2. Working to create public policies that use biomimicry as a solution to sustainability challenges
3. Encouraging companies that are profiting from biomimicry to provide financial support for biodiversity

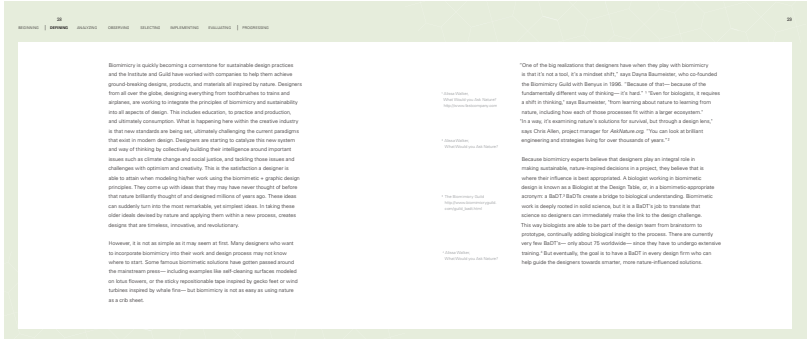
Thanks to the efforts and work of the biologists, designers and innovators at Biomimicry 3.8, more and more designers are realizing a simple truth when trying to find responsible, ecological solutions: If we're trying to do it, chances are, nature already did it better."

pg 26 - 27

INDUSTRY STANDARDS

Modern Design Practices

pg 28 - 29



18

BIOMIMING | DEFINING | ANALYZING | OBSERVING | SELECTING | IMPLEMENTING | EVALUATING | PROGRESSING

19

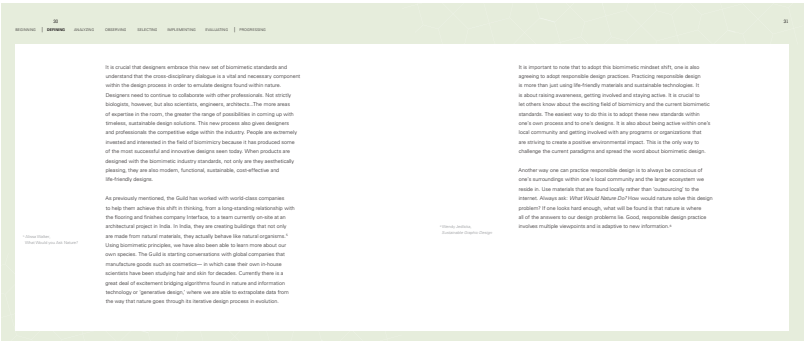
Biomimicry is quickly becoming a cornerstone for sustainable design practices and the Institute and Guild have worked with companies to help them achieve ground-breaking designs, products, and materials all inspired by nature. Designers from all over the globe, designing everything from toothbrushes to trains and airplanes, are working to integrate the principles of biomimicry and sustainability into all aspects of design. This includes education, to practice and production, and ultimately consumption. What is happening here within the creative industry is that new standards are being set, ultimately challenging the current paradigms that exist in modern design. Designers are starting to catalyze this new system and way of thinking by collectively building their intelligence around important issues such as climate change and social justice, and tackling those issues and challenges with optimism and creativity. This is the satisfaction a designer is able to attain when modeling his/her work using the biomimetic + graphic design principles. They come up with ideas that they may have never thought of before that nature brilliantly thought of and designed millions of years ago. These ideas can suddenly turn into the most remarkable, yet simplest ideas. In taking these older ideals devised by nature and applying them within a new process, creates designs that are timeless, innovative, and revolutionary.

However, it is not as simple as it may seem at first. Many designers who want to incorporate biomimicry into their work and design process may not know where to start. Some famous biomimetic solutions have gotten passed around the mainstream press—including examples like self-cleaning surfaces modeled on lotus flowers, or the sticky repositionable tape inspired by gecko feet or wind turbines inspired by whale fins—but biomimicry is not as easy as using nature as a crib sheet.

"One of the big realizations that designers have when they play with biomimicry is that it's not a tool, it's a mindset shift," says Dayna Baumeister, who co-founded the Biomimicry Guild with Benyus in 1996. "Because of that—because of the fundamentally different way of thinking—it's hard." "Even for biologists, it requires a shift in thinking," says Baumeister, "from learning about nature to learning from nature, including how each of those processes fit within a larger ecosystem." "In a way, it's examining nature's solutions for survival, but through a design lens," says Chris Allen, project manager for AskNature.org. "You can look at brilliant engineering and strategies living for over thousands of years."[1]

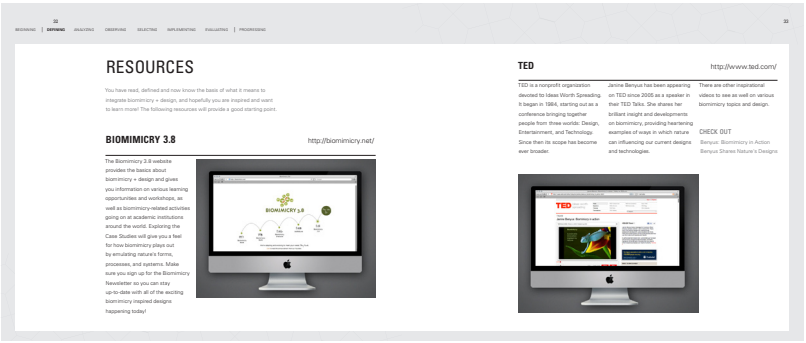
Because biomimicry experts believe that designers play an integral role in making sustainable, nature-inspired decisions in a project, they believe that is where their influence is best appropriated. A biologist working in biomimetic design is known as a Biologist at the Design Table, or, in a biomimetic-appropriate acronym: a BaDT.[2] BaDTs create a bridge to biological understanding. Biomimetic work is deeply rooted in solid science, but it is a BaDT's job to translate that science so designers can immediately make the link to the design challenge. This way biologists are able to be part of the design team from brainstorm to prototype, continually adding biological insight to the process. There are currently very few BaDT's— only about 75 worldwide— since they have to undergo extensive training.[3] But eventually, the goal is to have a BaDT in every design firm who can help guide the designers towards smarter, more nature-influenced solutions.

pg 30 - 31

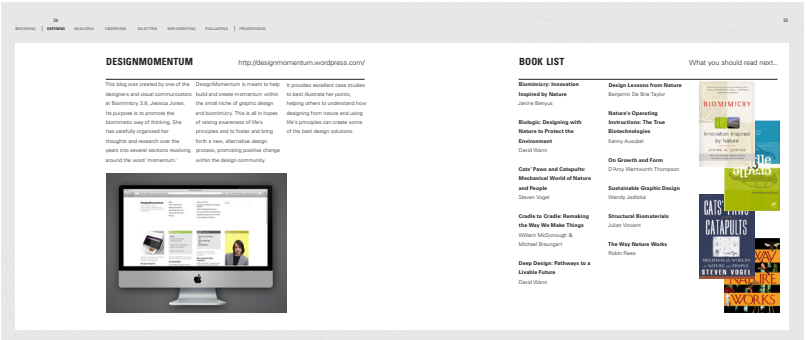


pg 32 - 33

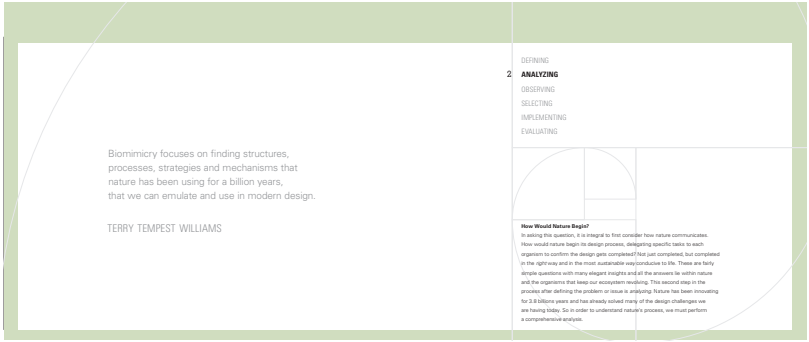
- A 3 column layout is used for the ‘Resource’ and ‘Case Studies’ sections so their is diversity for the user



pg 34 - 35



pg 36 - 37



4.3 Evaluation and Conclusion

4.3.1 User Evaluation Results

Overall, the responses I received from the user surveys and from face-to-face observations were very positive. Users responded very well to the layout and design of the final print application. The physical handling and care of the book by the user while they were flipping through the pages affirmed my design considerations and decisions. The separation and pacing of information within the sections allowed for a natural and easy flow created by an easier reading experience. Since the book is rich in text, it was meant to be broken down into digestible chunks to enhance reader comprehension. The overall layout and design of the final print application was thought-out in regards to consistency and cohesiveness. *To see the full survey and responses, please refer to the appendix section of this thesis documentation.*

4.3.2 Self Evaluation, Conclusion and Future Developments

My interest in sustainable graphic design and biomimicry has always been present within my years of design study and education. It is my belief that by providing other designers and non-designers alike with this graphic design + biomimicry resource guidebook, it will bring awareness and shed light upon the biomimetic design process, allowing it to be spread throughout society today. I wish to celebrate how to create innovative, sustainable and timeless design solutions by effectively integrating the methodologies and principles of both graphic design and biomimicry. This new process that has been proposed is meant to remind designers of the many benefits nature has to offer in helping us solve many of the problems that society is currently grappling with today. This book is also meant to encourage designers to think differently with a fresh outlook and mindset and to see how nature can positively impact modern design practices. The overall objective at hand is to create good design that also has the potential to *do* good, for the world and everything that encompasses it.

The goal of my final print application is to present users with the necessary knowledge, tools, and steps to know how to proceed and go about integrating biomimicry within their own unique process. I believe that through my thesis I have helped to define,analyze, observe, select, implement and evaluate all of the necessary steps and research in order for the users to take the information presented to create successful, sustainable design solutions.

In the future I will continue to pursue this biomimetic + graphic design integration and process by maintaining to post my documentation and my findings via various networks and channels of communication so others who have the same interest and passion as I do can share in the experience. I am hopeful that if others grasp onto this biomimetic design process, it will ultimately shape a more positive future for the upcoming generations, helping to reduce our carbon footprint and to learn how to live, create and make things while creating conditions conducive to life on earth.

Appendices

Appendix 1 Original Thesis Proposal

What would nature do?

Integrating Biomimicry + Graphic Design to
Effectively Create an Innovative Design Process

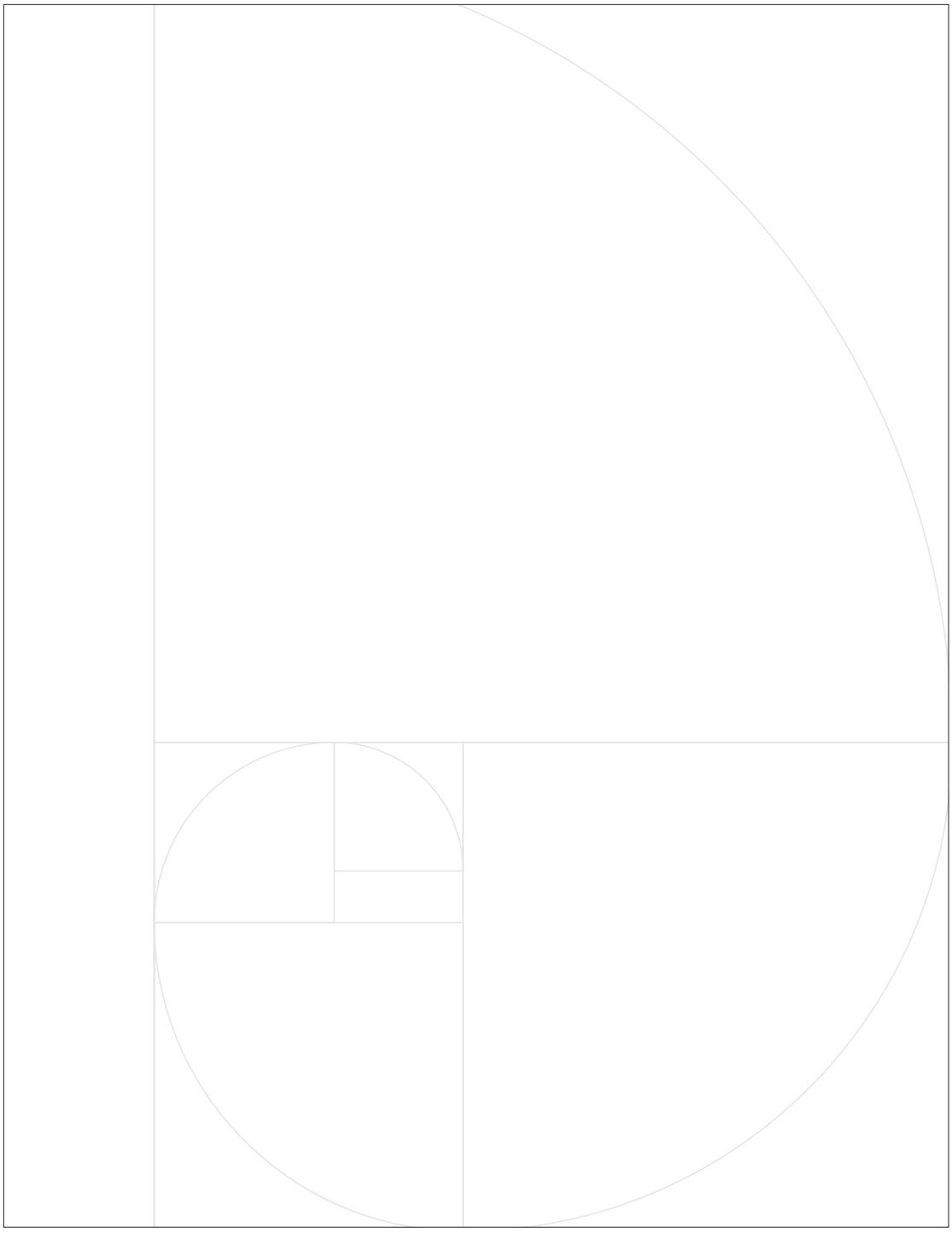
Margaret McKosky
Thesis Proposal for the Master of
Fine Arts Degree

Rochester Institute of Technology
College of Imaging Arts and Science
School of Design
Graphic Design
November 10, 2011

Bi•o•mim•ic•ry

the design and production of materials, structures, and systems that are modeled after biological entities and processes

from the Greek bios, life, mimesis, imitation



Situation Analysis

1 MARGARET MCKOSKY

Biomimicry is a relatively new discipline that studies nature's finest ideas and then attempts to imitate these designs and processes to solve human problems. It is simply innovation inspired by nature, or as Janine Benyus, one of the leading researchers of biomimicry today would say it is the conscious emulation of life's genius on the path to a sustainable future. The core concept is that nature over 3.8 billion years has already used its imaginative prowess to solve many of the problems that society is currently grappling with today. Nature has found what works, what is appropriate, and most importantly what lasts here on Earth. The failures are the fossils and the life that co-exists around us is the solution. Life found within nature is the secret to survival and the area to which we should be seeking the answers to our problems. However, in order to emulate nature's genius and reflect it onto our existing world, we must view nature in an entirely different manner. As the Biomimicry Guild and Institute believes, we need to look at nature as model, measure, and mentor. The Guild and its collaborators have developed a specific practical design tool called the Biomimicry Design Spiral based off of the Golden Selection for using nature as model which helps to further explain this notion. This Biomimicry Design Spiral will be the main scope and contributor of my research in developing a new, alternative graphic design process where identifying, interpreting, discovering, abstracting, emulating, and evaluating will be the key components. Sustainability is also an important contributing factor and reoccurring theme throughout the process of biomimicry. Essentially, it is the goal when using biomimicry within the realm of design to create hybrids of timeless, sustainable pieces. This is where nature as measure is introduced. In learning from the principle factors that work within nature, we can then embed them into our own sustainable solutions. Lastly, in viewing nature as mentor it is a summation of how one should view nature with a modern outlook. It is vital to note that biomimicry introduces an era based not on what we can extract from nature and all that it encompasses but on what we can potentially take away and learn from nature. When the world of biomimicry and design mesh, it has the power to create a beautiful landscape of opportunities.

The challenge at hand is to take these time-tested ideals nature has produced over the years and echo them to produce effective design solutions. By constituting nature as model, measure and as mentor, a new way of evaluating and creating effective design solutions will emerge out of the abyss of the already creative design process to an entirely new, innovative process full of potential. Biomimicry can be used as a tool to create more sustainable design solutions due to it being a design methodology itself, occurring in the ideation phase of the graphic design process rather than the execution phase. For instance, a designer would start with a human design problem, identifying the root of challenge and then review how nature would go about solving this problem. *What would nature do?* It is crucial to look at the natural form, process, and system already found within nature so one can mimic its process within the ideation stage. There will be a cross fertilization of ideas along the way, but in the end the juggernaut of biomimicry will shed a new light onto the field of graphic design, creating an avant-garde mode of thinking which in turn will lead to an alternate, innovative and revolutionary graphic design process.

BIOMIMICRY + GRAPHIC DESIGN 2

Problem Statement

Will this new and innovative design process of integrating biomimicry with graphic design help designers to think differently, using nature as their inspiration in order create more sustainable design solutions?

3 MARGARET MCKOSKY

Designers are problem solvers. We apply our creative talents to finding new and appropriately innovative solutions to common questions. These questions include how to best articulate a brand, how to connect with a particular audience or how to communicate across cultural boundaries. Now more than ever, there are bigger problems than just brands and connecting to consumers. There are fundamental needs such as equality, education, food, water, community, peace, justice and hope. It is instrumental that designers constantly ask themselves, what is my responsibility? How am I affecting or bettering the world I reside in? Once designers ask themselves these questions, they come to the realization that their work has the potential to both be good and *do* good. In using nature as inspiration throughout the design process, it will allow for designers to think about how their design solution will interact within it surroundings. For instance, how will my design affect the environment, will my design be sustainable, how will people interpret or use this design solution, and how will this solution stand the test of time? Change is inevitable, change is constant and everything evolves. The main concern for designers should be, how will I go about detecting and predicting these changes? Are all designers able to see the road signs that lie ahead and are they willing to challenge themselves to overcome their own heuristic bias to design for the greater good?

In mimicking the design found within organisms, graphic designers can observe the natural forms, functions, proportions, geometric compositions, and processes that already work in order to produce more sustainable solutions. However, there is a great divide within the world of designers; all having their own way of creating and designing. Within this divergent and warring factions of designers, you have the younger, chaotic and non-linear generation versus the older, formulaic and linear generation. Not all will agree with this new biomimetic mind-set, yet it is still important to institute as it has the possibility to bring about massive change in the design sphere and how designers think in their process. It will force designers to innovate, experiment, push and adapt further than they ever have before. It is important to think of the the power and ability designers have to solve the existing human problems that we grapple with today, and how in looking at nature we will find all of the secrets. Designers should want to *zig* while everyone else *zags* and challenge the current pessimistic zeitgeist mentality and sensibility seen in and throughout society. Within this new design process and solution also comes a need to also change how we consume, teach, spend, think; essentially live. Viewing the world in an entirely different manner, turning the world as we know it upside down to reveal the true belly of the beast and all of the perfection nature has attained over the years is not only necessary, it is crucial for survival. It is crucial so designers can create solutions that not only solve human problems but also stand the test of time and positively influence their environments. Nature is the great designer and in looking at biomimicry within design, we will be able to open our minds up to a new realm of possibilities and truly appreciate the design guidelines nature has given us.

We are on the cusp of great change. Will one curl up at the thought of this or embrace this new mode of thinking to help shape a positive future for design, people, and most importantly our planet?

BIOMIMICRY + GRAPHIC DESIGN 4

Survey of Literature

5 MARGARET MCKOSKY

Biomimicry

1 **Nature's Operating Instructions / The True Biotechnologies**

Ausubel, Kenny. Nature's Operating Instructions / The True Biotechnologies. University of California Press, 2004.

This book is divided into five parts. Part I opens a window onto biomimicry and the myriad imaginative technological applications drawn from nature that have shown the capacity to decontaminate our polluted world. Part II looks directly at the ways of the land and how people are using those to help the land heal itself. Part III provides a cautionary glimpse into the basic conceptual flaws embedded in the design of current so-called biotechnologies and illustrates some of the consequent threats to the environment. Part IV applies nature's operating instructions to industry's central production processes and touches on some of the thorny political and economic factors blocking their wider acceptance. Part V searches the human heart and spirit to invoke our unique cultural facility to create an earth-honoring civilization. This book further relays the notion that biomimicry is innovation inspired by nature, looking to nature as a teacher and mentor. I will use this resource in helping my research of the biomimetic process within design.

2 **Innovation Inspired by Nature / Biomimicry**

Benyus, Janine M. Innovation Inspired by Nature / Biomimicry. William Morrow and Company, Inc., 1997.

"Why Biomimicry Now? Biomimicry is a new science that studies nature's models and then imitates or takes inspiration from these designs and processes to solve human problems, e.g., a solar cell inspired by a leaf." Janine Benyus does a superb job in providing a thorough explanation of the biomimetic world and all that it encompasses. The book itself is told in her own narrative where she dispenses case studies that she either witnessed or was actually a part of. Within the case studies she presents how we can learn from nature today, using nature's perfect sense of design that has been successful for billions of years as a solution model for the most basic human problems. Benyus describes biomimicry in a variety of areas and environments which are concisely laid out from chapter to chapter. For instance, she examines biomimicry in the way we feed ourselves, how we harness energy, how we heal ourselves, how we conduct business and so on. What I have surveyed in this book is specifically how biomimicry can inspire and innovate how we make things fitting form to function; e.g., weaving fibers like a spider. Benyus bestows a lot of useful information regarding biomimicry within design and I will use this book extensively throughout my research.

3 **The Way Nature Works**

Rees, Robin. The Way Nature Works. Mitchell Beazley International Ltd., 1992.

This books specifically targets the way the Earth and its living organisms function providing scientific answers to questions that arise when looking at the world around us. It encompasses the Earth and its atmosphere through evolution and on to the extraordinary diversity of form and behavior seen among today's living species. This resource will be especially helpful in looking and researching how organisms function in their natural environments and how nature's good design over the years has lead to survival for all living species among their habitats.

4 **Design Lessons from Nature**

Taylor, Benjamin De Brie. Design Lessons from Nature.
Watson-Guptill Publications, 1974.

This source is unique in the fact that it contains the substance of talks that were given to a freshman class at Pratt Institute in the 1967—1968 academic year. It contains photographs of the work done by the students in the class. The course was established in an attempt to display the relationships that exist between nature and art and to propose problems which "would represent a logical sequence in the development of drawing skills as well as in the understanding of design problems." Although this book is dated it still serves as a valuable source in examining nature as art form and the relationship that exists between the two.

5 **Structural Biomaterials**

Vincent, Julian. Structural Biomaterials. Princeton University Press, 1990.

This book is very scientific and engineering in nature going deep into the chemistry, biology, and physics that make up the structure of various biomaterials. The only section of this book that is of particular interest is in the sixth chapter where the function and design of bone in organisms is discussed. This will help me to understand the scientific process behind the creation of nature's best designs.

6 **Cats Paws and C;atapults / Mechanical Worlds of Nature & People**

Vogel, Steven. Cats Paws and Catapults / Mechanical Worlds of Nature & People.
W.W. Norton & Company, Inc., 1998.

This book looks at the subject area of biomechanics —the technology of life, at the mechanical view of nature. It poses some very good questions and modes of thought such as why should nature do what she does in the best possible way and why does nature provide a model for what we want to do? Vogel wants "to ruffle our tendency to view nature as the gold standard for design and as a great source of technological breakthroughs." This source will be extremely helpful in looking at the cross fertilization of technology, design, and nature.

7 MARGARET MCKOSKY

7 **Biologic / Designing with Nature to Protect the Environment**
Wann, David. Biologic / Designing with Nature to Protect the Environment. Johnson Printing Company, 1994.

Wann does an excellent job in explaining the need for society to rethink the way it views nature, desiring for a 'redesign of culture" where nature is appreciated rather than devalued. This book will primarily be used in the methodology process and how Wann perceives how nature can be used in design to help promote sustainability and provide solutions to some of human's most basic problems.

Design

8 **Graphic Design Theory / Readings from the Field**
Armstrong, Helen & Lupton, Ellen. Graphic Design Theory / Readings from the Field. Princeton Architectural Press, 2009.

As Ellen Lupton states in the foreword, "This book is an introduction to graphic design theory. Each selection, written in its own time and place across a century of design evolution, explores the aesthetic and social purposes of design practice....Theory is all about the question "why?" The process of becoming a designer is focused largely on *how*: how to use software, how to solve problems, how to organize information, how to get clients, how to work with printers, and so on." This book will be very effective in the theory and design ideation of my application as well as the methodological process. In observing actual case studies, it will be helpful to see solutions other designers came up with and the process they went about to solve the problem they were given, since as designers it is our role to be problem solvers as well.

9 **Geometry of Design / Studies in Proportion and Composition**
Elam, Kimberly. Geometry of Design / Studies in Proportion and Composition. Princeton Architectural Press, 2001.

Elam stresses that "too often designers see conceptual ideas suffer during the process of realization and ideation in large part because the designer did not understand the visual principles of geometric composition. These principles include an understanding of classic proportioning systems such as the golden selection and root rectangles, as well as ratios and proportion, interrelationships of form, and regulating lines." This book not only goes into detail of natural geometric form seen within organisms but it goes even further to show a wide selection of professional posters, products, and buildings that are visually analyzed by these principles nature herself devised. This source will be helpful in my process in comparing existing structures that are based on natural form and how these forms are not only more aesthetically pleasing but sustainable as well.

10 **Design Writing Research: Writing on Graphic Design**
Lupton, Ellen & Miller, J. Abbott. Design Writing Research: Writing on Graphic Design. Kiosk, 1996.

Lupton and Miller deconstruct writing on graphic design into three separate categories: theory, media, and history. Their aims and process are neatly summarized in the three noun manifesto— Design/Writing/Research. They use design itself as a tool of explication and analysis and Miller even "suggests a greater than usual density of connections in the wiring of verbal and visual meaning." This will be helpful when writing my own theory on integrating biomimicry within the existing field of graphic design.

11 **Skin / Surface Substance + Design**
Lupton, Ellen. Skin / Surface Substance + Design. Princeton Architectural Press, 2002.

"Surging fears and ambitions fuel scientific discovery and stimulate the creation and consumption of new technologies. Design reflects and shapes our understanding of the world; it is both symptom and cure. As a practice embedded in the fabric of technology and commerce, design responds critically to the very culture it serves to replicate and extend." In comparing human skin as the largest encompassing organ of humans to materials used throughout design, Lupton shows how design is a complete reflection of how we view the world. Design becomes a signal of intention, meant to convey the meaning of something. This will be used in the research phase of looking at how various materials can be applied to natural forms and processes.

12 **Mixing Messages / Graphic Design in Contemporary Culture**
Lupton, Ellen. Mixing Messages / Graphic Design in Contemporary Culture. Princeton Architectural Press, 1996.

"Graphic Design as a process involves the making of visual statements and their use and revision by clients, audiences, and other designers. *Mixing* characterizes the social life of graphic design. Visual communications elicit divergent responses in a crowded landscape of competing messages. The meaning of signs and styles shifts with the context in which they are sent and received." Throughout this book, Lupton raises the issues and concerns with looking at visual symbols within the culture they are presented and how their perceptions change over time due to the shifting identity seen in contemporary culture. This will be useful in the development of my application since I will have to be aware and concerned with how people will perceive my approach to this new hybrid biomimetic design process. I need to make sure that the messages I am sending through visual communication are understood and can be spread to the masses.

13 **Cradle to Cradle / Remaking the Way We Make Things**

McDonough, William & Braungart, Michael. Cradle to Cradle / Remaking the Way We Make Things. North Point Press, 2002.

This book represents "one step toward a radically different approach to designing and producing the objects we use and enjoy, an emerging movement we see as the next industrial revolution. This revolution is founded on nature's surprisingly effective design principles, on human creativity and prosperity, and on respect, fair play, and goodwill. It has the power to transform both industry and environmentalism, as we know them." Cradle to Cradle is a revolutionary book in which McDonough and Braungart wish to raise awareness regarding sustainability and hold ourselves responsible to the negative stigma we have laid upon the earth in regards to pollution, global warming, and so on. "Human industry has been in full swing for little over a century, yet is has brought about a decline in almost every ecosystem on the planet. Nature doesn't have a design problem. People do." This is exactly what I want to illustrate and prove in my thesis and show how in using a different approach and design process, designers can turn our ecological footprint in the right direction. To design products and systems that celebrate the abundance of human creativity, culture, and productivity that are so intelligent and safe our species can leave an ecological footprint to delight in, not lament in.

14 **Deep Design / Pathways to a Liveable Future**

Wann, David. Deep Design / Pathways to a Liveable Future. Island Press, 1996.

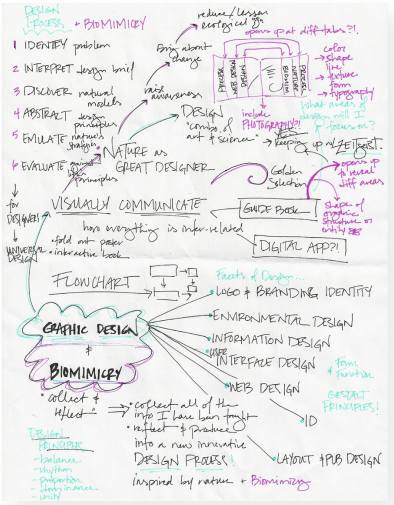
"We live in a designed world. Everything from where we live, to how we get to work, to what we eat is the result of an endless series of decisions by countless individuals. But rarely is thought given to whole processes or attention paid to how systems should work together. As a result, much of the design in our world is flawed, and with each new technological advance we find ourselves faced with yet another unintended consequence." Wann explores a new way of thinking about design and what the ultimate goal of design should be. The design process should begin with a question and be sensitive to living systems without the side effects of pollution, erosion, congestion, and stress. Sustainability is a key factor in designing for the environment and Wann states how he believes we can achieve the best case scenario of diversity, conservation, and care-taking in the future.

Design Ideation

11 MARGARET MCKOSKY

Mind Mapping

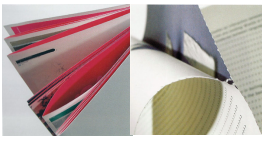
- Conceptually Visualizing Ideas related to biomimicry + design
- Brainstorming of Print Application
- Looking at the multiple facets of design to apply to my new design process

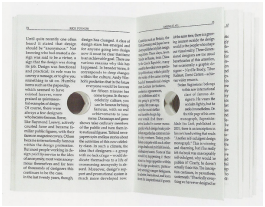


Flow Chart

- Print Application— Book
- Interactive, pop-outs, folds, unique layout
- Appropriate look and feel for subject matter of biomimicry + graphic design

Interactive Elements





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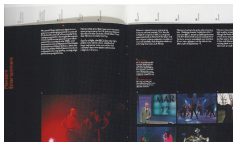
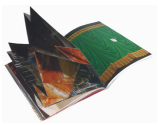
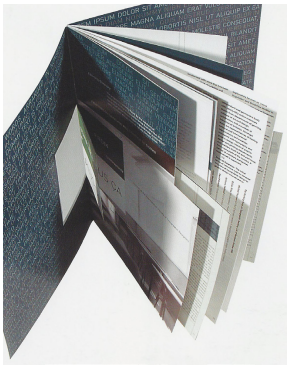






BIOMIMICRY + GRAPHIC DESIGN 14

Methodology

15 MARGARET MCKOSKY

Objective

The purpose of the design process is to go through multiple ideation and brainstorming phases in order to devise enough variations so one can then critique the entire selection before choosing a successful final solution. The *What Would Nature Do?* Design Process Book will be an interactive print application demonstrating how by integrating biomimicry with the graphic design process, designers can create more sustainable design solutions to solve some of the problems humans are grappling with today and design for the greater good. The main objective within this new process book is to establish a set of guidelines and questions for each facet of graphic design so the designer can reference it in their own ideation phase of their design process. The new process book is meant to push the boundaries further and demonstrate a different way of thinking. Following an initial stage of research and understanding of the subject matter, design strategies and processes can begin to develop, followed by implementation and dissemination.

Target Audience

The specific target audience will be designers at the collegiate level or higher who are knowledgeable and trained within the field of graphic design.

Approach

1 Research biomimicry and existing graphic design processes, as well as experimental book formats, layouts and grid structures. Also look at the existing human problems that still need solutions. *Can apply these problems as case study examples within the What Would Nature Do design process and guide book.*

2 *Collect & Reflect*
Take all of the research and information I gathered and take some time to reflect, asking myself how it all can be combined and integrated within one another. This will lead me to the brainstorming phase of the new process in figuring out how biomimicry and innovation that is found within nature can be interconnected within the world of graphic design.

3 Brainstorm steps of the new design process for each facet of design— information, web/interface, branding & identity, environmental.

4 Implement the chosen design process in my print application and make sure to give examples of case studies within each facet to show the steps of the process in a clear and efficient manner.

5 Usability testing and collection of feedback. Evaluate and push further.

6 Final print application— What Would Nature Do? design process and guide book.

7 Presentation and further dissemination.
Presentation and thesis show may include additional panels to help show what is portrayed within the final book in a more direct display.

BIOMIMICRY + GRAPHIC DESIGN 16

Implementation Strategies

17 MARGARET MCKOSKY

In addition to graphic design, this thesis requires a background knowledge and degree of understanding of the field of biomimicry. I have done a great deal of research on the subject thus far, and plan on continuing to research throughout my thesis documentation process. The scope of my thesis is one that requires only enough time to achieve a final print application book. However, a digital application is planned after the dissemination to continue the process, personal time permitting. Along with the software list below, I will use a Canon digital camera to record various visuals that will be used as well as using an Apple iMac desktop computer & Apple MacBook Pro laptop to help build my thesis.

Software

Adobe Creative Suite

- InDesign
- Illustrator
- Photoshop

After Thesis Dissemination / Personal Continuation of Digital Application

- Dreamweaver
- After Effects

Dissemination

19 MARGARET MCKOSKY

I plan on distributing my findings for future audience interaction by posting it on my thesis website, *http://www.maggiesgdthesis.weebly.com,* as well as my personal website, *http://www.margaretmckosky.com*. I will also leave printed copies with RIT Archives and the Graduate Graphic Design Program as well as submit electronic copies to the RIT Archives, Digital Media Library, and ProQuest/UMI. Lastly, I will submit my final thesis and research findings to design and communication journals that may have interest in my subject area as well as graphic design competitions.

The following are publications and organizations I may potentially contact or inform of my thesis research and published printed book.

Magazine
Communication Arts
HOW
I.D./Information Design Journal
Print

Institutes
Biomimicry Guild
Biomimicry Institute

Awards & Competitions

I.D. Magazine / Annual Design Review
November 1, 2011
$ per entry

HOW Magazine / Your Best Work Design Awards
December 1, 2011
$95 per entry

One Show Design / Onederful
January 31, 2012
$ per entry

Print Magazine / Regional Design Annual
April 1, 2011
$65 per entry

Communication Arts / Design Competition
May 11, 2012
$40 per entry

UCDA Design Competition
October 16, 2012
$40 Member fee/$60 Non-Member fee

These are possibilities but not ALL will be entered.

Evaluation Plan

21 MARGARET MCKOSKY

The evaluation criteria and process are important in order to see if my objectives are being met and people are clearly demonstrating an understanding of the subject matter of my thesis. To assess my print application book and to determine the success of my objectives I will look for short term impacts on my audience. I will do a qualitative research study in the form of an online survey and actual face-to-face user interaction of my book. The participants will assess what they liked, disliked, and would like to have seen in my application. After analyzing the feedback I will be able to improve my application by pushing it further and implementing my findings.

Considerations

- Do people understand the idea of biomimicry within design and understand each entity as they exist separately?
- Has the message reached the intended target audience?
- Is awareness being addressed for the need of change within design to solve the existing human problems?
- Do people believe my process is credible?
- Are people understanding my message?
- Are there positive reactions?
- Have I made an impact and upheld my responsibility as a designer?

Success Determinants

- Message has reached it's intended audience
- My Book has made an impact on my intended target audience and engaged them with a different mind-set
- Raised awareness and promoted change
- People were able to clearly understand the hybrid of biomimicry + graphic design and my solution of the new design process

How

- Face-to-Face Observation of User-Interaction
- Online Surveys

BIOMIMICRY + GRAPHIC DESIGN 22

Pragmatic Considerations

23 MARGARET MCKOSKY

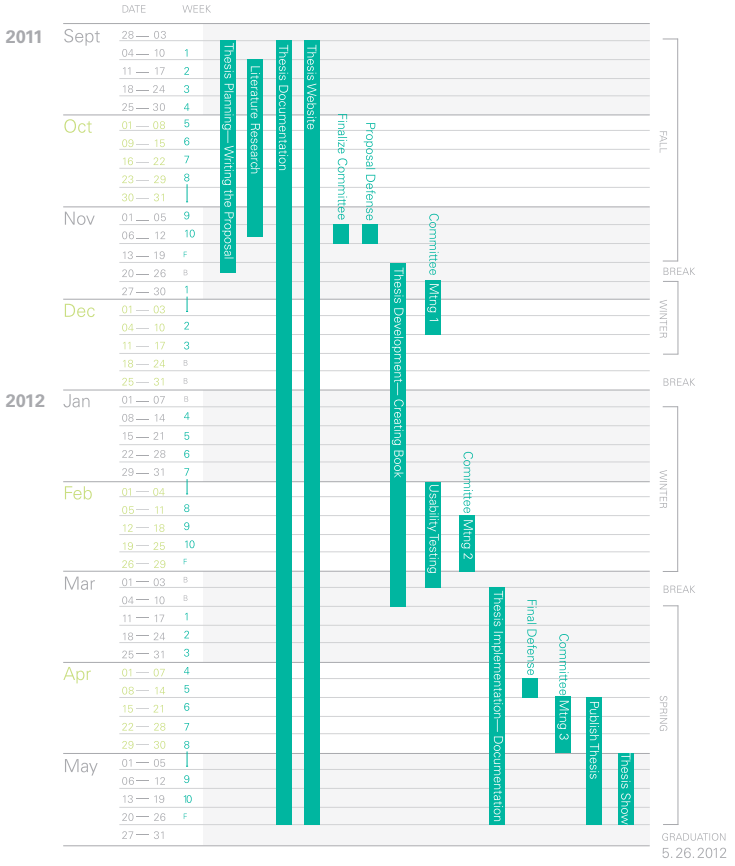
Budget	Thesis Show Print Materials, Promotional Posters, Business Cards, Book	$450
	Dissemination Submitting final thesis research and book to competitions	$250
	Publishing Proposal (2)— GGD and myself Final Bound Copies (3)— GGD, library, and myself	$100
	Total	**$800**

Numbers are an estimation of what I can expect to spend throughout my thesis documentation. All expenses are subject to change and will, most likely.

BIOMIMICRY + GRAPHIC DESIGN 24

Timeline

25 MARGARET MCKOSKY



Milestones

- ○ Finalize Committee
- ○ Proposal Defense
- ○ Proposal Accepted
- ○ Committee Mtng 1
- ○ Committee Mtng 2
- ○ Committee Mtng 3
- ○ Final Defense
- ○ Thesis Show
- ○ Graduation / 5. 26. 2012

Bibliography

27 MARGARET MCKOSKY

Biomimicry

Ausubel, Kenny. Nature's Operating Instructions / The True Biotechnologies. University of California Press, 2004.

Benyus, Janine M. Innovation Inspired by Nature / Biomimicry. William Morrow and Company, Inc., 1997.

Rees, Robin. The Way Nature Works. Mitchell Beazley International Ltd., 1992.

Taylor, Benjamin De Brie. Design Lessons from Nature. Watson-Guptill Publications, 1974.

Vincent, Julian. Structural Biomaterials. Princeton University Press, 1990.

Vogel, Steven. Cats Paws and Catapults / Mechanical Worlds of Nature & People. W.W. Norton & Company, Inc., 1998.

Wann, David. Biologic / Designing with Nature to Protect the Environment. Johnson Printing Company, 1994.

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Elam, Kimberly. Geometry of Design / Studies in Proportion and Composition. Princeton Architectural Press, 2001.

Armstrong, Helen & Lupton, Ellen. Graphic Design Theory / Readings from the Field. Princeton Architectural Press, 2009.

Fawcett-Tang, Roger. Experimental Formats.2 / Books Brochures Catalogs. RotoVision, 2005.

Lupton, Ellen & Miller, J. Abbott. Design Writing Research: Writing on Graphic Design. Kiosk, 1996.

Lupton, Ellen. Mixing Messages / Graphic Design in Contemporary Culture. Princeton Architectural Press, 1996.

Lupton, Ellen. Skin / Surface Substance + Design. Princeton Architectural Press, 2002.

McDonough, William & Braungart, Michael. Cradle to Cradle / Remaking the Way We Make Things. North Point Press, 2002.

Simmons, Christopher. Just Design.

Wann, David. Deep Design / Pathways to a Liveable Future. Island Press, 1996.

Final Signature

29 MARGARET MCKOSKY

Thesis Proposal for the Masters of Fine Arts Degree

Rochester Institute of Technology
College of Imaging Arts and Science
School of Design
Graphic Design

Title What would nature do?
Integrating Biomimicry + Graphic Design to
Effectively Create an Innovative Design Process

Submission Margaret McKosky

Date November 10, 2011

Thesis Committee Approval

Chief Advisor — Date
Nancy Ciolek, Associate Professor, Graphic Design

Associate Advisor — Date
Bruce Ian Meader, Associate Professor, Graphic Design

Associate Advisor — Date
Lorrie Frear, Associate Professor, Graphic Design

Associate Advisor — Date
Josh Owen, Associate Professor, Industrial Design

School of Design Administrative Chair — Date
Patti Lachance, Associate Professor, School of Design

Thesis Website
http://www.maggiesgdthesis.weebly.com/

Appendix 2 Bibliography

Armstrong, Helen. Graphic Design Theory. New York: Princeton Architectural Press, 2009.

Ausubel, Kenny. Nature's Operating Instructions: The True Biotechnologies. Sierra Club Books, 2004.

Benyus, Janine. Biomimicry: Innovation Inspired by Nature. New York: William Morrow and Company, Inc., 1997.

Benyus, Janine. "Biomimicry in Action." <www.ted.com>

Biomimicry 3.8 Website. <http://biomimicry.net/>

Buxton, Bill. Sketching User Experiences. Oxford: Elsevier Inc., 2007.

Designers Accord Website. <http://www.designersaccord.org/>

Elam, Kimberly. Geometry of Design. New York: Princeton Architectural Press, 2001.

Faludi, Jeremy. "Biomimicry for Green Design" Worldchanging: Change Your Thinking.

Fast Company Website. <http://www.fastcompany.com/>

Field, Michael. Symmetry in Chaos: A Search for Pattern in Mathematics, Art and Nature. Philadelphia: Society for Industrial and Applied Mathematics, 2009.

Fawcett-Tang, Roger. Experimental Formats 2: Books Brochures Catalogs. RotoVision, 2005.

Gauguin, Jan. Designing Diagrams. Amsterdam: BIS Publishers, 2011.

Hastrich, Carl. Bouncing Ideas Blog. <http://bouncingideas.wordpress.com/>

Hawken, Paul, Amory and L. Hunter Lovins. Natural Capitalism. Boston: Little, Brown and Company, 1999.

Jedlicka, Wendy. Sustainable Graphic Design. Hoboken: John Wiley & Sons, Inc. 2010.

Jones, Jessica. DesignMomentum Blog. <http://designmomentum.wordpress.com>

Knight, Carolyn; Glaser, Jessica. Diagrams: Innovative Solutions for Graphic Designers. RotoVision SA, 2009.

Lidwell, William, Kritina Holden, and Julia Butler. Universal Principles of Design: 100 ways to Enhance Usability, Influence Perception, Increase Appeal, Make Better Design Decisions, and Teach through Design. Beverly: Rockport Publishers, Inc., 2003.

Lupton, Ellen. Graphic Design Thinking: Beyond Brainstorming. New York: Princeton Architectural Press, 2011.

Lupton, Ellen. Mixing Messages: Graphic Design in Contemporary Culture. New York: Princeton Architectural Press, 1996.

Lupton, Ellen and J. Abbott Miller. Design Writing Research: Writing on Graphic Design. New York: Kiosk, 1996.

Lupton, Ellen and Jennifer Cole Phillips. Graphic Design The New Basics. New York: Princeton Architectural Press, 2008.

Lupton, Ellen. Skin: Surface Substance + Design. New York: Princeton Architectural Press, 2002.

Mandelbrot, Benoit. The Fractal Geometry of Nature. Boston: W.H. Freeman and Company, 1983.

McDonough, William and Michael Braungart. Cradle to Cradle: Remaking the Way We Make Things. New York: North Point Press, 2002.

McNab, Maggie. Decoding Design: Understanding and Using Symbols in Visual Communication. Cincinnati: HOW Books, 2008.

Michalko, Michael. Thinkertoys. Berkeley: Ten Speed Press, 2006.

Pawlyn, Michael. Exploration Architecture. <http://www.explorationarchitecture.com>

Rees, Robin. The Way Nature Works. Mitchell Beazley International Ltd., 1992.

RIT Taga Publication Website. <http://taga.rit.edu/2011/>

Scott, Katie. "Biomimicry in Architecture and the start of the Ecological Age." Wired. <http://www.wired.co.uk/>

Simmons, Christopher. Just Design. Cincinnati: HOW Books, 2011.

Taylor, Benjamin De Brie. Design Lessons from Nature. New York: Watson-Guptill Publications, 1974.

The Biomimicry Guild. <http://www.biomimicryguild.com/>

The Biomimicry Institute. <http://www.biomimicryinstitute.org/>

The 17th Heinz Awards <http://www.heinzawards.net>

Thompson, D'Arcy Wentworth. On Growth and Form. Great Britain: Cambridge University Press, 1961.

Tilford, Dave. Sustainable Consumption: Why Consumption Matters. Sierra Club, 2000.

Trondreau, Beth. Layout Essentials: 100 Principles for Using Grids. Beverly: Rockport Publishers, Inc., 2009.

Tufte, Edward. Envisioning Information. Graphics Press, 1990.

Tufte, Edward. Visual Explanantions. Graphics Press, 1997.

Vincent, Julian. Structural Biomaterials. New York: Princeton University Press, 1990.

Vogel, Steven. Cats Paws and Catapults: Mechanical World of Nature and People. W. W. Norton & Company, 1998.

Walker, Alissa. "What Would you Ask Nature?" Fast Company. <http://www.fastcompany.com/>

Wallschlaeger, Charles, and Cynthia Busic-Snyder. Basic Visual Concepts and Principles for Artists, Architects and Designers. Boston: McGraw Hill, 1992.

Wann, David. Biologic: Designing with Nature to Protect the Environment. Boulder: Johnson Printing Company, 1994.

Wann, David. Deep Design: Pathways to a Liveable Future. Washington, DC: Island Press, 1996.

Appendix 3 Blank User Survey

GRAPHIC DESIGN + BIOMIMICRY

USER SURVEY

Initial Information

Gender: ○ Male ○ Female

Age: ○ 18 - 24 ○ 25 - 30 ○ 31 - 36 ○ 37 - 45 ○ 46 - 55 ○ 56 - 65 ○ Above 65

Thank you for participating in this survey. Your detailed answers are extremely helpful in determining the success of this thesis. Any insight or personal experience you can provide concerning the fields of graphic design and/or biomimicry is very valuable and I encourage you to please offer your knowledge and expertise. Any of the information you provide with be used for educational purposes in the documentation of this thesis and I will not be asking you any personal information like your name, phone number, or address just your gender and age as seen above. If you have any questions or concerns please feel free to contact me at mlm8492@g.rit.edu.

Design Skills

Are you a Designer? ○ Yes ○ No

If yes, What level designer would you consider yourself? ○ Beginner ○ Intermediate ○ Advanced

Did you go to school for design (or are currently enrolled)? ○ Yes ○ No

If so, what degree do you have (and/or on track of obtaining)? ○ Bachelor (BFA) ○ Master (MFA)

If no, Would you still consider yourself somewhat knowledgeable of the basic principles and elements of design? ○ Yes ○ No

Do you think you would be able to critique a design piece? ○ Yes ○ No

Knowledge of Biomimicry

Do you know what biomimicry is? ○ Yes ○ No

Are you aware of the Biomimicry Institute or Guild? ○ Yes ○ No

If yes, do you have any personal experience working within the field (specifically design related)? ○ Yes ○ No

If so, please explain:

Graphic Design + Biomimicry | User Survey 1

Resource Guidebook Success Determinants

After reading or looking through the Graphic Design + Biomimicry book, were you able to understand and grasp the following concepts:

(Please fill in at least *one* circle for each)

	Yes		Somewhat		No
• What biomimicry is?	○	○	○	○	○
• How to apply the six stages of the process to a real-world design scenario?	○	○	○	○	○
• How to integrate biomimetic design into corporations and creative sessions?	○	○	○	○	○
• How to take Nature's 14 Design principles and apply them to your process?	○	○	○	○	○
• How the methodologies of graphic design + biomimicry integrate to form this process?	○	○	○	○	○
• How the Sierpinski triangle and fractal patterns are applied to the process?	○	○	○	○	○
• How to use natural algorithms to create tessellation patterns?	○	○	○	○	○
• What materials and tools you should use in biomimetic design?	○	○	○	○	○
• How nature can play a positive role nature within modern design practices?	○	○	○	○	○
• Did the icons, charts, infographics, and diagrams help?	○	○	○	○	○
• Did you find the resources and case studies to be useful?	○	○	○	○	○
• Were the two system solutions helpful and necessary?	○	○	○	○	○

Do you think the Graphic Design + Biomimicry Resource Guidebook is successful? ○ Yes ○ No

Was the overall design of the book appropriate and aesthetically pleasing? ○ Yes ○ No

Did the design and layout of the book make it easier to comprehend? ○ Yes ○ No

Please list any improvements that could be made:

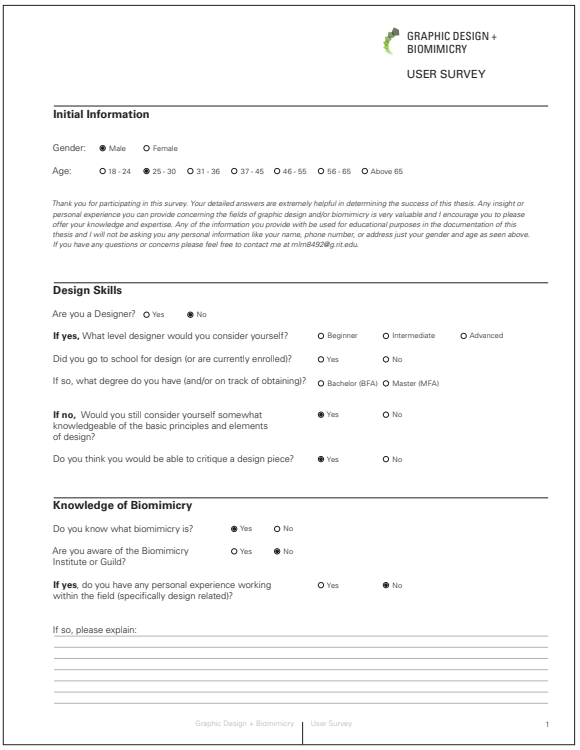
Comments Overall:

Appendix 4 User Survey Results

Disclaimer

The following are direct survey responses and have not been altered in any way. The responses were obtained electronically via email where users filled out the .pdf forms and then sent them back. Comments are intentionally not edited to ensure authenticity or information and transparency in results.

User 1



GRAPHIC DESIGN + BIOMIMICRY

USER SURVEY

Initial Information

Gender: ◉ Male ○ Female

Age: ○ 18 - 24 ◉ 25 - 30 ○ 31 - 36 ○ 37 - 45 ○ 46 - 55 ○ 56 - 65 ○ Above 65

Thank you for participating in this survey. Your detailed answers are extremely helpful in determining the success of this thesis. Any insight or personal experience you can provide concerning the fields of graphic design and/or biomimicry is very valuable and I encourage you to please offer your knowledge and expertise. Any of the information you provide with be used for educational purposes in the documentation of this thesis and I will not be asking you any personal information like your name, phone number, or address just your gender and age as seen above. If you have any questions or concerns please feel free to contact me at mlm8492@g.rit.edu.

Design Skills

Are you a Designer? ○ Yes ◉ No

If yes, What level designer would you consider yourself? ○ Beginner ○ Intermediate ○ Advanced

Did you go to school for design (or are currently enrolled)? ○ Yes ○ No

If so, what degree do you have (and/or on track of obtaining)? ○ Bachelor (BFA) ○ Master (MFA)

If no, Would you still consider yourself somewhat knowledgeable of the basic principles and elements of design? ◉ Yes ○ No

Do you think you would be able to critique a design piece? ◉ Yes ○ No

Knowledge of Biomimicry

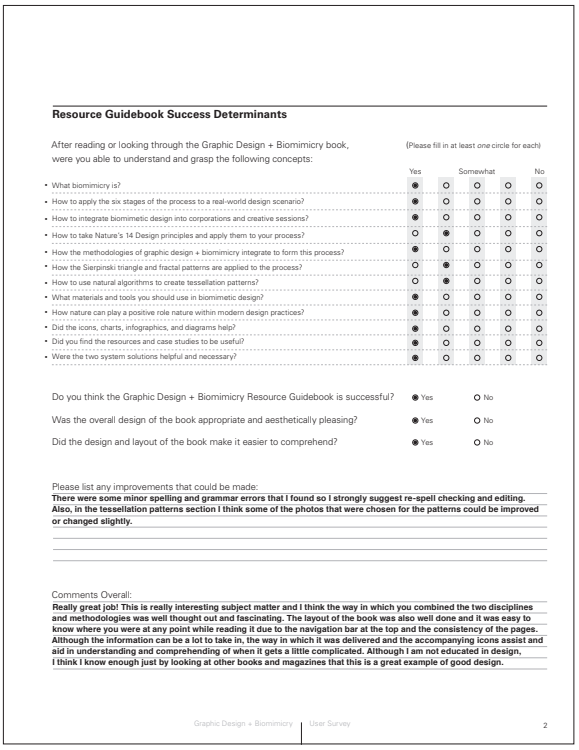
Do you know what biomimicry is? ◉ Yes ○ No

Are you aware of the Biomimicry Institute or Guild? ○ Yes ◉ No

If yes, do you have any personal experience working within the field (specifically design related)? ○ Yes ◉ No

If so, please explain:

Graphic Design + Biomimicry | User Survey 1



Resource Guidebook Success Determinants

After reading or looking through the Graphic Design + Biomimicry book, were you able to understand and grasp the following concepts:

(Please fill in at least *one* circle for each)

	Yes		Somewhat		No
• What biomimicry is?	◉	○	○	○	○
• How to apply the six stages of the process to a real-world design scenario?	◉	○	○	○	○
• How to integrate biomimetic design into corporations and creative sessions?	◉	○	○	○	○
• How to take Nature's 14 Design principles and apply them to your process?	○	◉	○	○	○
• How the methodologies of graphic design + biomimicry integrate to form this process?	◉	○	○	○	○
• How the Sierpinski triangle and fractal patterns are applied to the process?	○	◉	○	○	○
• How to use natural algorithms to create tessellation patterns?	○	◉	○	○	○
• What materials and tools you should use in biomimetic design?	◉	○	○	○	○
• How nature can play a positive role nature within modern design practices?	◉	○	○	○	○
• Did the icons, charts, infographics, and diagrams help?	◉	○	○	○	○
• Did you find the resources and case studies to be useful?	◉	○	○	○	○
• Were the two system solutions helpful and necessary?	◉	○	○	○	○

Do you think the Graphic Design + Biomimicry Resource Guidebook is successful? ◉ Yes ○ No

Was the overall design of the book appropriate and aesthetically pleasing? ◉ Yes ○ No

Did the design and layout of the book make it easier to comprehend? ◉ Yes ○ No

Please list any improvements that could be made:

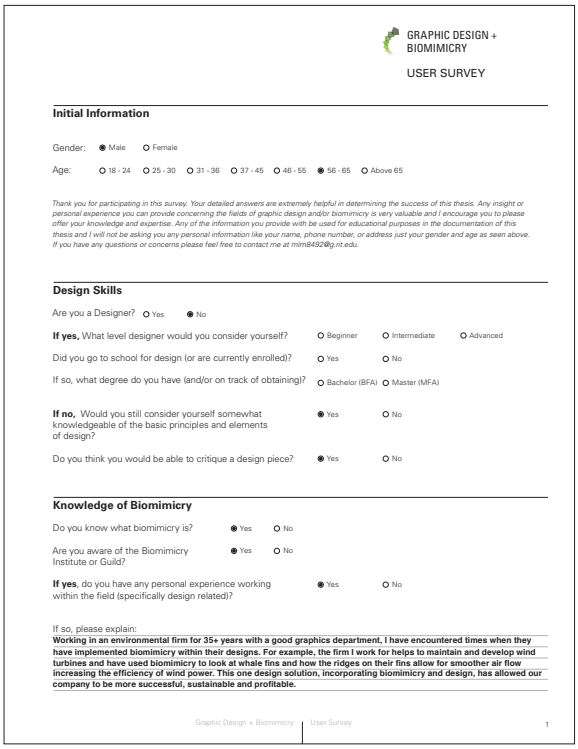
There were some minor spelling and grammar errors that I found so I strongly suggest re-spell checking and editing. Also, in the tesselation patterns section I think some of the photos that were chosen for the patterns could be improved or changed slightly.

Comments Overall:

Really great job! This is really interesting subject matter and I think the way in which you combined the two disciplines and methodologies was well thought out and fascinating. The layout of the book was also well done and it was easy to know where you were at any point while reading it due to the navigation bar at the top and the consistency of the pages. Although the information can be a lot to take in, the way in which it was delivered and the accompanying icons assist and aid in understanding and comprehending of when it gets a little complicated. Although I am not educated in design, I think I know enough just by looking at other books and magazines that this is a great example of good design.

Graphic Design + Biomimicry | User Survey 2

User 2



GRAPHIC DESIGN + BIOMIMICRY

USER SURVEY

Initial Information

Gender: ◉ Male ○ Female

Age: ○ 18 - 24 ○ 25 - 30 ○ 31 - 36 ○ 37 - 45 ○ 46 - 55 ◉ 56 - 65 ○ Above 65

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Knowledge of Biomimicry

Do you know what biomimicry is? ◉ Yes ○ No

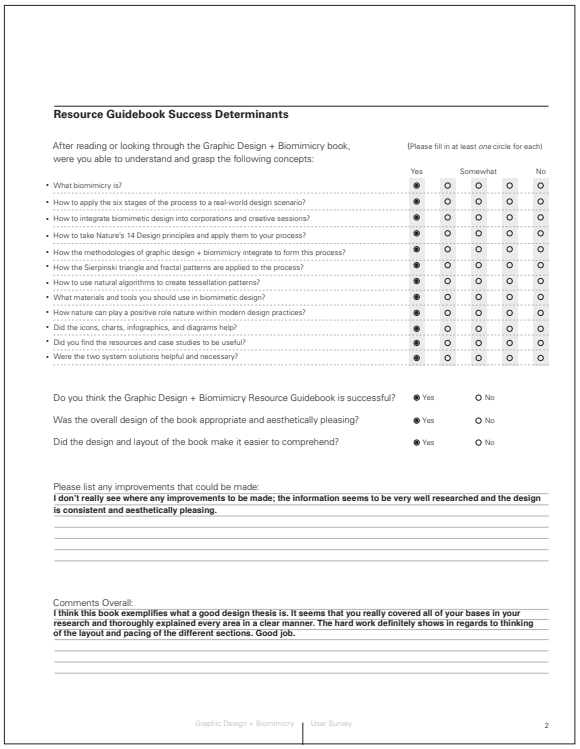
Are you aware of the Biomimicry Institute or Guild? ◉ Yes ○ No

If yes, do you have any personal experience working within the field (specifically design related)? ◉ Yes ○ No

If so, please explain:

Working in an environmental firm for 35+ years with a good graphics department, I have encountered times when they have implemented biomimicry within their designs. For example, the firm I work for helps to maintain and develop wind turbines and have used biomimicry to look at whale fins and how the ridges on their fins allow for smoother air flow increasing the efficiency of wind power. This one design solution, incorporating biomimicry and design, has allowed our company to be more successful, sustainable and profitable.

Graphic Design + Biomimicry | User Survey 1



Resource Guidebook Success Determinants

After reading or looking through the Graphic Design + Biomimicry book, were you able to understand and grasp the following concepts:

(Please fill in at least *one* circle for each)

	Yes	Somewhat	No
• What biomimicry is?	◉	○ ○ ○	○
• How to apply the six stages of the process to a real-world design scenario?	◉	○ ○ ○	○
• How to integrate biomimetic design into corporations and creative sessions?	◉	○ ○ ○	○
• How to take Nature's 14 Design principles and apply them to your process?	◉	○ ○ ○	○
• How the methodologies of graphic design + biomimicry integrate to form this process?	◉	○ ○ ○	○
• How the Sierpinski triangle and fractal patterns are applied to the process?	◉	○ ○ ○	○
• How to use natural algorithms to create tessellation patterns?	◉	○ ○ ○	○
• What materials and tools you should use in biomimetic design?	◉	○ ○ ○	○
• How nature can play a positive role nature within modern design practices?	◉	○ ○ ○	○
• Did the icons, charts, infographics, and diagrams help?	◉	○ ○ ○	○
• Did you find the resources and case studies to be useful?	◉	○ ○ ○	○
• Were the two system solutions helpful and necessary?	◉	○ ○ ○	○

Do you think the Graphic Design + Biomimicry Resource Guidebook is successful? ◉ Yes ○ No

Was the overall design of the book appropriate and aesthetically pleasing? ◉ Yes ○ No

Did the design and layout of the book make it easier to comprehend? ◉ Yes ○ No

Please list any improvements that could be made:

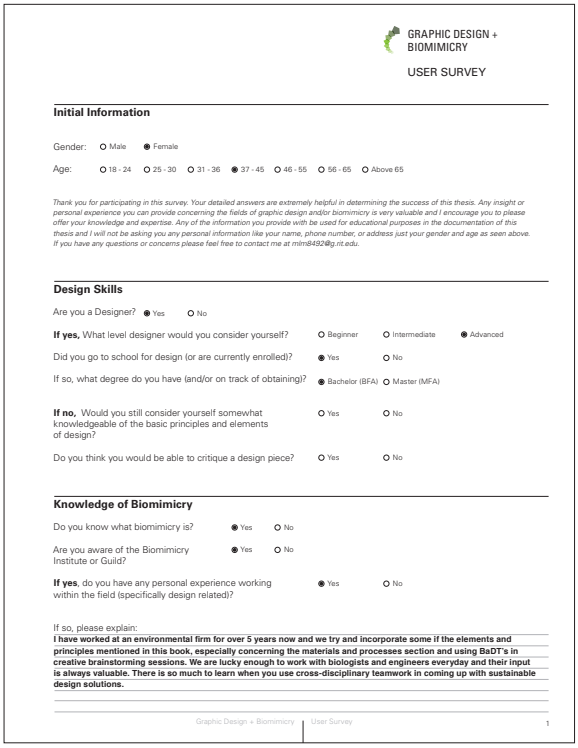
I don't really see where any improvements to be made; the information seems to be very well researched and the design is consistent and aesthetically pleasing.

Comments Overall:

I think this book exemplifies what a good design thesis is. It seems that you really covered all of your bases in your research and thoroughly explained every area in a clear manner. The hard work definitely shows in regards to thinking of the layout and pacing of the different sections. Good job.

Graphic Design + Biomimicry | User Survey 2

User 3



GRAPHIC DESIGN + BIOMIMICRY

USER SURVEY

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Do you know what biomimicry is? ◉ Yes ○ No

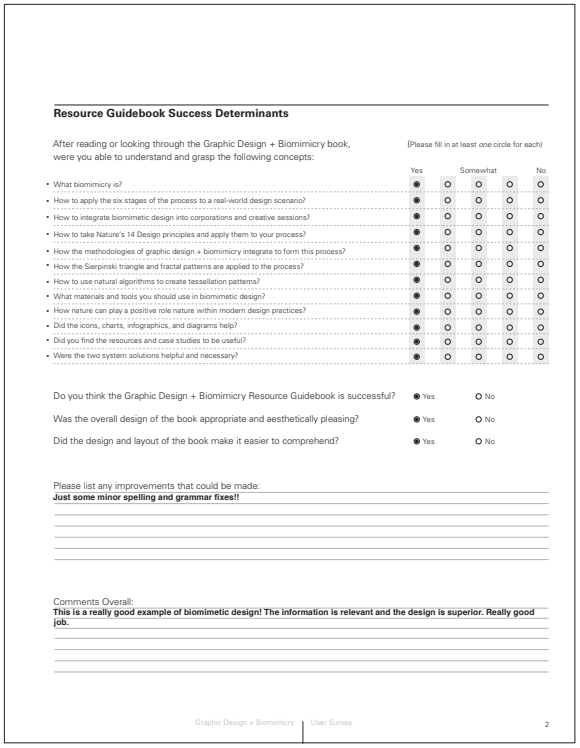
Are you aware of the Biomimicry Institute or Guild? ◉ Yes ○ No

If yes, do you have any personal experience working within the field (specifically design related)? ◉ Yes ○ No

If so, please explain:

I have worked at an environmental firm for over 5 years now and we try and incorporate some if the elements and principles mentioned in this book, especially concerning the materials and processes section and using BaDT's in creative brainstorming sessions. We are lucky enough to work with biologists and engineers everyday and their input is always valuable. There is so much to learn when you use cross-disciplinary teamwork in coming up with sustainable design solutions.

Graphic Design + Biomimicry | User Survey 1



Resource Guidebook Success Determinants

After reading or looking through the Graphic Design + Biomimicry book, were you able to understand and grasp the following concepts:

(Please fill in at least *one* circle for each)

	Yes	Somewhat	No
• What biomimicry is?	◉	○ ○ ○	○
• How to apply the six stages of the process to a real-world design scenario?	◉	○ ○ ○	○
• How to integrate biomimetic design into corporations and creative sessions?	◉	○ ○ ○	○
• How to take Nature's 14 Design principles and apply them to your process?	◉	○ ○ ○	○
• How the methodologies of graphic design + biomimicry integrate to form this process?	◉	○ ○ ○	○
• How the Sierpinski triangle and fractal patterns are applied to the process?	◉	○ ○ ○	○
• How to use natural algorithms to create tessellation patterns?	◉	○ ○ ○	○
• What materials and tools you should use in biomimetic design?	◉	○ ○ ○	○
• How nature can play a positive role nature within modern design practices?	◉	○ ○ ○	○
• Did the icons, charts, infographics, and diagrams help?	◉	○ ○ ○	○
• Did you find the resources and case studies to be useful?	◉	○ ○ ○	○
• Were the two system solutions helpful and necessary?	◉	○ ○ ○	○

Do you think the Graphic Design + Biomimicry Resource Guidebook is successful? ◉ Yes ○ No

Was the overall design of the book appropriate and aesthetically pleasing? ◉ Yes ○ No

Did the design and layout of the book make it easier to comprehend? ◉ Yes ○ No

Please list any improvements that could be made:

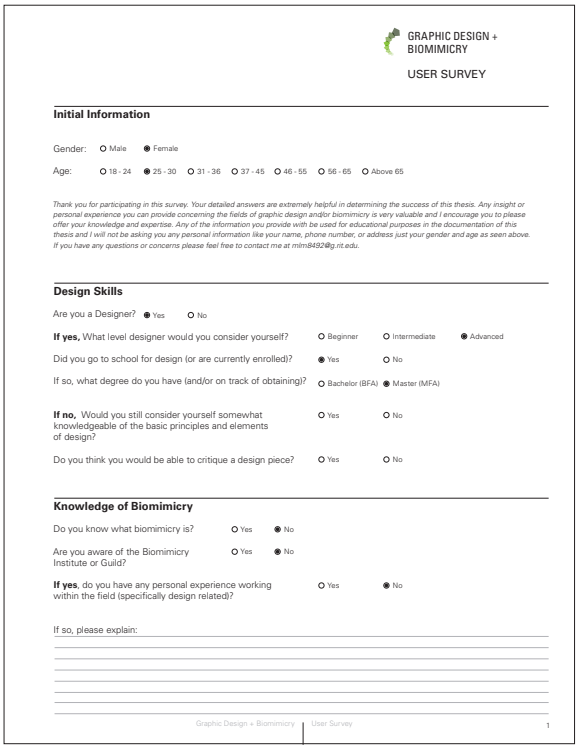
Just some minor spelling and grammar fixes!!

Comments Overall:

This is a really good example of biomimetic design! The information is relevant and the design is superior. Really good job.

Graphic Design + Biomimicry | User Survey 2

User 4



GRAPHIC DESIGN + BIOMIMICRY

USER SURVEY

Initial Information

Gender: ○ Male ◉ Female

Age: ○ 18 - 24 ◉ 25 - 30 ○ 31 - 36 ○ 37 - 45 ○ 46 - 55 ○ 56 - 65 ○ Above 65

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If no, Would you still consider yourself somewhat knowledgeable of the basic principles and elements of design? ○ Yes ○ No

Do you think you would be able to critique a design piece? ○ Yes ○ No

Knowledge of Biomimicry

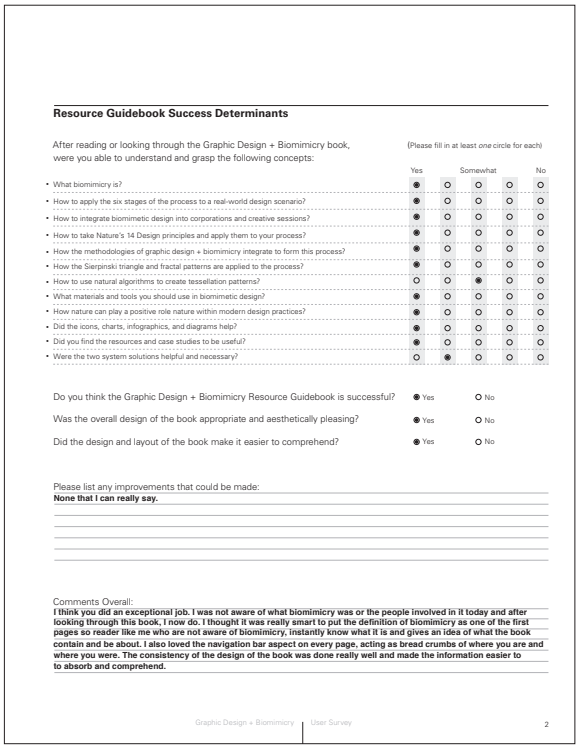
Do you know what biomimicry is? ○ Yes ◉ No

Are you aware of the Biomimicry Institute or Guild? ○ Yes ◉ No

If yes, do you have any personal experience working within the field (specifically design related)? ○ Yes ◉ No

If so, please explain:

Graphic Design + Biomimicry | User Survey 1



Resource Guidebook Success Determinants

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	Yes	Somewhat	No
• What biomimicry is?	◉	○	○
• How to apply the six stages of the process to a real-world design scenario?	◉	○	○
• How to integrate biomimetic design into corporations and creative sessions?	◉	○	○
• How to take Nature's 14 Design principles and apply them to your process?	◉	○	○
• How the methodologies of graphic design + biomimicry integrate to form this process?	◉	○	○
• How the Sierpinski triangle and fractal patterns are applied to the process?	◉	○	○
• How to use natural algorithms to create tessellation patterns?	○	◉	○
• What materials and tools you should use in biomimetic design?	◉	○	○
• How nature can play a positive role nature within modern design practices?	◉	○	○
• Did the icons, charts, infographics, and diagrams help?	◉	○	○
• Did you find the resources and case studies to be useful?	◉	○	○
• Were the two system solutions helpful and necessary?	○	◉	○

Do you think the Graphic Design + Biomimicry Resource Guidebook is successful? ◉ Yes ○ No

Was the overall design of the book appropriate and aesthetically pleasing? ◉ Yes ○ No

Did the design and layout of the book make it easier to comprehend? ◉ Yes ○ No

Please list any improvements that could be made:

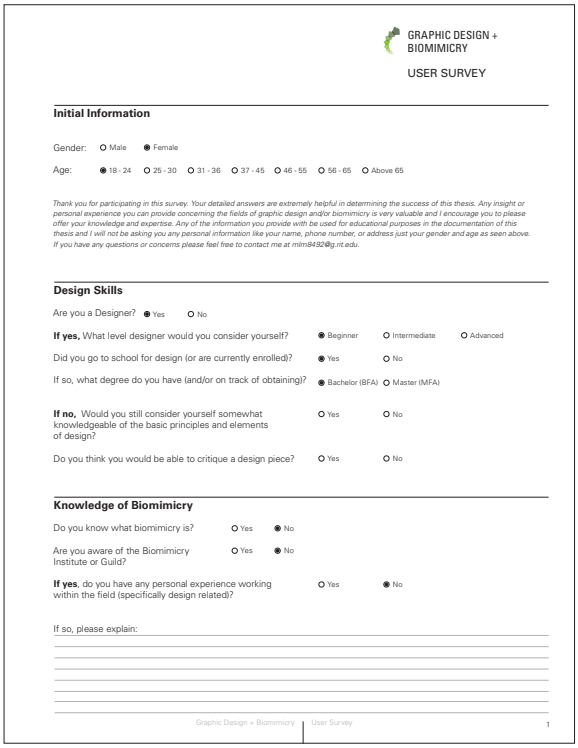
None that I can really say.

Comments Overall:

I think you did an exceptional job. I was not aware of what biomimicry was or the people involved in it today and after looking through this book, I now do. I thought it was really smart to put the definition of biomimicry as one of the first pages so reader like me who are not aware of biomimicry, instantly know what it is and gives an idea of what the book contain and be about. I also loved the navigation bar aspect on every page, acting as bread crumbs of where you are and where you were. The consistency of the design of the book was done really well and made the information easier to to absorb and comprehend.

Graphic Design + Biomimicry | User Survey 2

User 5



GRAPHIC DESIGN + BIOMIMICRY

USER SURVEY

Initial Information

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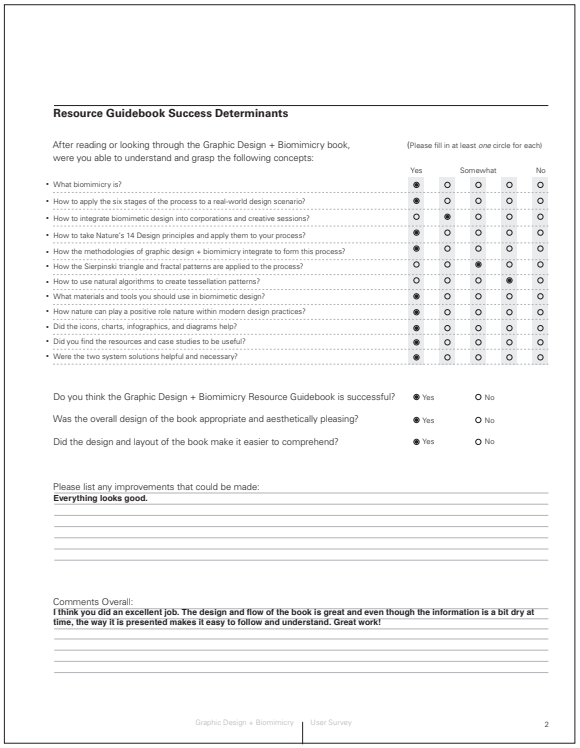
Graphic Design + Biomimicry | User Survey 1



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• How the Sierpinski triangle and fractal patterns are applied to the process?	○	○	◉
• How to use natural algorithms to create tessellation patterns?	○	○	○
• What materials and tools you should use in biomimetic design?	◉	○	○
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Do you think the Graphic Design + Biomimicry Resource Guidebook is successful? ◉ Yes ○ No

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Did the design and layout of the book make it easier to comprehend? ◉ Yes ○ No

Please list any improvements that could be made:

Everything looks good.

Comments Overall:

I think you did an excellent job. The design and flow of the book is great and even though the information is a bit dry at time, the way it is presented makes it easy to follow and understand. Great work!

Graphic Design + Biomimicry | User Survey 2

User 6

GRAPHIC DESIGN + BIOMIMICRY

USER SURVEY

Initial Information

Gender: ◉ Male ○ Female

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Did the design and layout of the book make it easier to comprehend? ◉ Yes ○ No

Please list any improvements that could be made:

There are some grammatical errors and mis-spellings that should be corrected!

Comments Overall:

I really like the book overall! The color palette and type choices were very appropriate. The design choices work and aid in the comprehension of the information. I really enjoyed looking through and reading this book.

User 7

GRAPHIC DESIGN + BIOMIMICRY

USER SURVEY

Initial Information

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If so, what degree do you have (and/or on track of obtaining)? ○ Bachelor (BFA) ○ Master (MFA)

If no, Would you still consider yourself somewhat knowledgeable of the basic principles and elements of design? ◉ Yes ○ No

Do you think you would be able to critique a design piece? ◉ Yes ○ No

Knowledge of Biomimicry

Do you know what biomimicry is? ◉ Yes ○ No

Are you aware of the Biomimicry Institute or Guild? ◉ Yes ○ No

If yes, do you have any personal experience working within the field (specifically design related)? ○ Yes ◉ No

If so, please explain:

Resource Guidebook Success Determinants

After reading or looking through the Graphic Design + Biomimicry book, were you able to understand and grasp the following concepts: (Please fill in at least *one* circle for each)

	Yes	Somewhat	No
• What biomimicry is?	◉	○ ○	○
• How to apply the six stages of the process to a real-world design scenario?	○	◉ ○	○
• How to integrate biomimetic design into corporations and creative sessions?	○	◉ ○	○
• How to take Nature's 14 Design principles and apply them to your process?	○	○ ◉	○
• How the methodologies of graphic design + biomimicry integrate to form this process?	◉	○ ○	○
• How the Sierpinski triangle and fractal patterns are applied to the process?	○	◉ ○	○
• How to use natural algorithms to create tessellation patterns?	○	○ ◉	○
• What materials and tools you should use in biomimetic design?	◉	○ ○	○
• How nature can play a positive role nature within modern design practices?	◉	○ ○	○
• Did the icons, charts, infographics, and diagrams help?	◉	○ ○	○
• Did you find the resources and case studies to be useful?	◉	○ ○	○
• Were the two system solutions helpful and necessary?	◉	○ ○	○

Do you think the Graphic Design + Biomimicry Resource Guidebook is successful? ◉ Yes ○ No

Was the overall design of the book appropriate and aesthetically pleasing? ◉ Yes ○ No

Did the design and layout of the book make it easier to comprehend? ◉ Yes ○ No

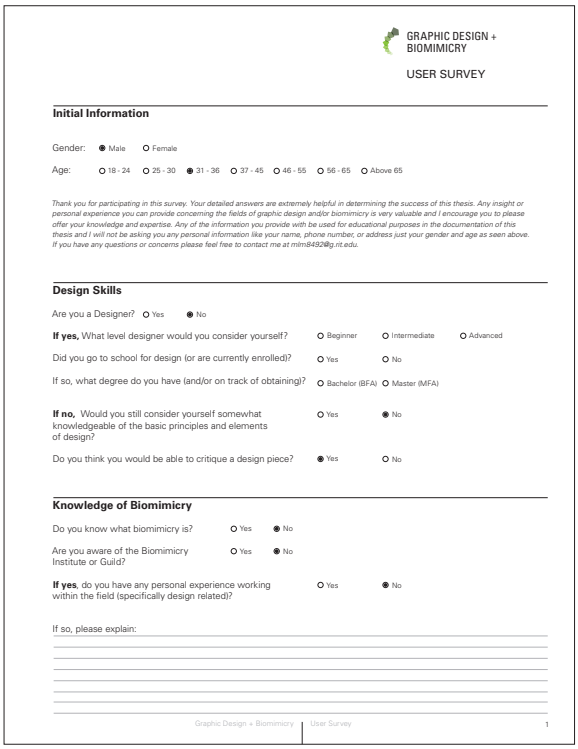
Please list any improvements that could be made:

The only suggestion I would make is to darken the different patterns for each chapter. The first two show up nicely, but the rest get a little lost and they are hard to see.

Comments Overall:

Really good job. Your hard work shows and I think that this could even be published in the future if you wanted to do that! Even though I am not a designer, I can see where the thought was in maintaining consistency throughout the different sections and it is really well designed. Great work!

User 8



GRAPHIC DESIGN + BIOMIMICRY

USER SURVEY

Initial Information

Gender: ◉ Male ○ Female

Age: ○ 18 - 24 ○ 25 - 30 ◉ 31 - 36 ○ 37 - 45 ○ 46 - 55 ○ 56 - 65 ○ Above 65

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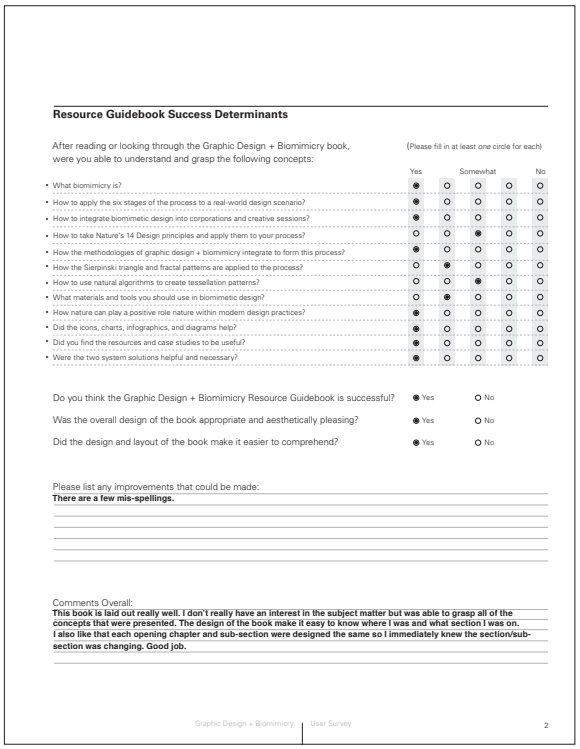
If so, please explain:

Graphic Design + Biomimicry | User Survey 1



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• What biomimicry is?	◉	○	○
• How to apply the six stages of the process to a real-world design scenario?	◉	○	○
• How to integrate biomimetic design into corporations and creative sessions?	◉	○	○
• How to take Nature's 14 Design principles and apply them to your process?	○	◉	○
• How the methodologies of graphic design + biomimicry integrate to form this process?	◉	○	○
• How the Sierpinski triangle and fractal patterns are applied to the process?	○	◉	○
• How to use natural algorithms to create tessellation patterns?	○	◉	○
• What materials and tools you should use in biomimetic design?	○	◉	○
• How nature can play a positive role nature within modern design practices?	◉	○	○
• Did the icons, charts, infographics, and diagrams help?	◉	○	○
• Did you find the resources and case studies to be useful?	◉	○	○
• Were the two system solutions helpful and necessary?	◉	○	○

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Did the design and layout of the book make it easier to comprehend? ◉ Yes ○ No

Please list any improvements that could be made:

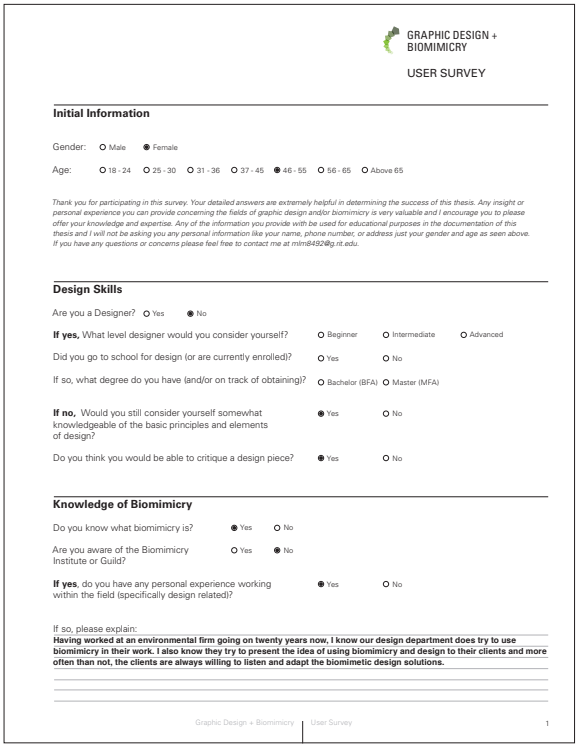
There are a few mis-spellings.

Comments Overall:

This book is laid out really well. I don't really have an interest in the subject matter but was able to grasp all of the concepts that were presented. The design of the book make it easy to know where I was and what section I was on. I also like that each opening chapter and sub-section were designed the same so I immediately knew the section/sub-section was changing. Good job.

Graphic Design + Biomimicry | User Survey 2

User 9



GRAPHIC DESIGN + BIOMIMICRY

USER SURVEY

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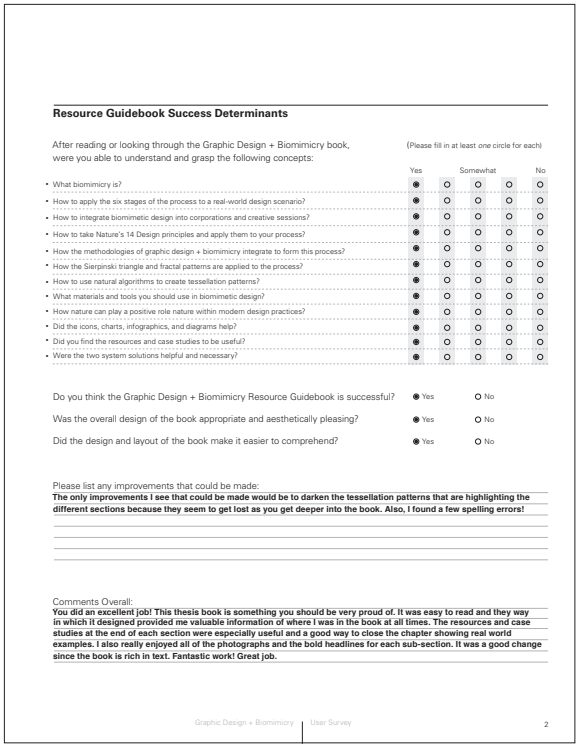
Are you aware of the Biomimicry Institute or Guild? ○ Yes ◉ No

If yes, do you have any personal experience working within the field (specifically design related)? ◉ Yes ○ No

If so, please explain:

Having worked at an environmental firm going on twenty years now, I know our design department does try to use biomimicry in their work. I also know they try to present the idea of using biomimicry and design to their clients and more often than not, the clients are always willing to listen and adapt the biomimetic design solutions.

Graphic Design + Biomimicry | User Survey 1



Resource Guidebook Success Determinants

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(Please fill in at least *one* circle for each)

	Yes	Somewhat	No
• What biomimicry is?	◉	○	○
• How to apply the six stages of the process to a real-world design scenario?	◉	○	○
• How to integrate biomimetic design into corporations and creative sessions?	◉	○	○
• How to take Nature's 14 Design principles and apply them to your process?	◉	○	○
• How the methodologies of graphic design + biomimicry integrate to form this process?	◉	○	○
• How the Sierpinski triangle and fractal patterns are applied to the process?	◉	○	○
• How to use natural algorithms to create tessellation patterns?	◉	○	○
• What materials and tools you should use in biomimetic design?	◉	○	○
• How nature can play a positive role nature within modern design practices?	◉	○	○
• Did the icons, charts, infographics, and diagrams help?	◉	○	○
• Did you find the resources and case studies to be useful?	◉	○	○
• Were the two system solutions helpful and necessary?	◉	○	○

Do you think the Graphic Design + Biomimicry Resource Guidebook is successful? ◉ Yes ○ No

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Did the design and layout of the book make it easier to comprehend? ◉ Yes ○ No

Please list any improvements that could be made:

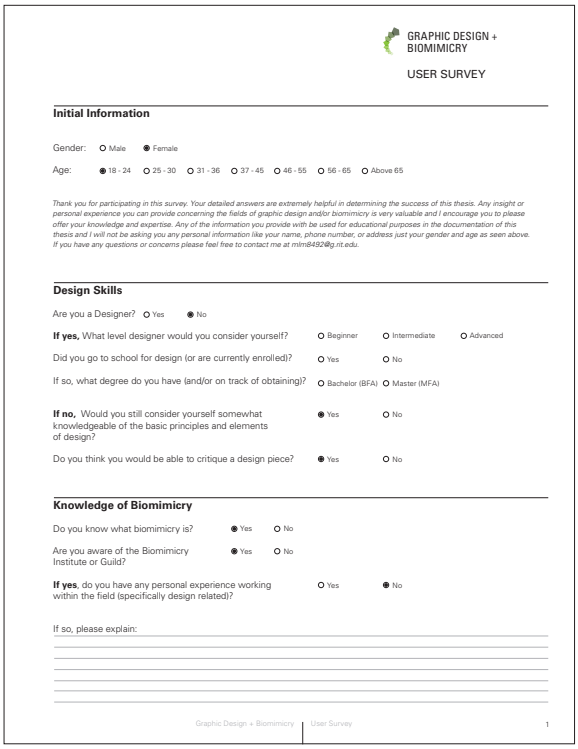
The only improvements I see that could be made would be to darken the tessellation patterns that are highlighting the different sections because they seem to get lost as you get deeper into the book. Also, I found a few spelling errors!

Comments Overall:

You did an excellent job! This thesis book is something you should be very proud of. It was easy to read and they way in which it designed provided me valuable information of where I was in the book at all times. The resources and case studies at the end of each section were especially useful and a good way to close the chapter showing real world examples. I also really enjoyed all of the photographs and the bold headlines for each sub-section. It was a good change since the book is rich in text. Fantastic work! Great job.

Graphic Design + Biomimicry | User Survey 2

User 10



GRAPHIC DESIGN + BIOMIMICRY

USER SURVEY

Initial Information

Gender: ○ Male ◉ Female

Age: ◉ 18 - 24 ○ 25 - 30 ○ 31 - 36 ○ 37 - 45 ○ 46 - 55 ○ 56 - 65 ○ Above 65

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Design Skills

Are you a Designer? ○ Yes ◉ No

If yes, What level designer would you consider yourself? ○ Beginner ○ Intermediate ○ Advanced

Did you go to school for design (or are currently enrolled)? ○ Yes ○ No

If so, what degree do you have (and/or on track of obtaining)? ○ Bachelor (BFA) ○ Master (MFA)

If no, Would you still consider yourself somewhat knowledgeable of the basic principles and elements of design? ◉ Yes ○ No

Do you think you would be able to critique a design piece? ◉ Yes ○ No

Knowledge of Biomimicry

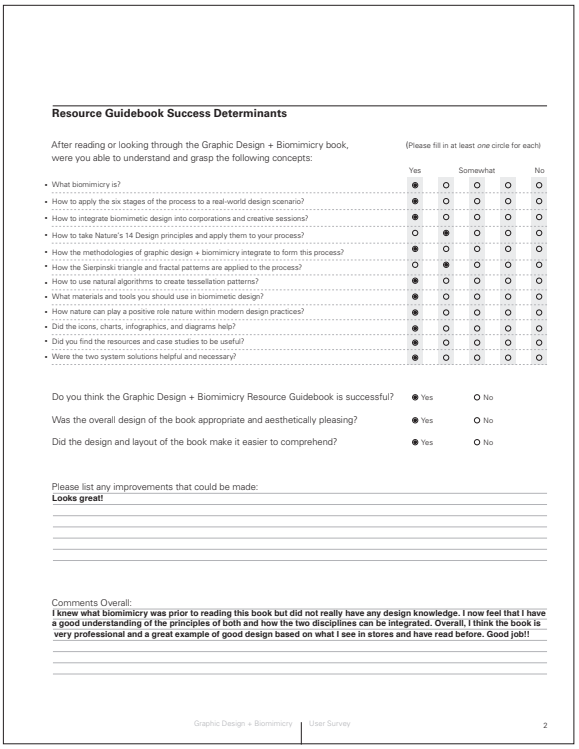
Do you know what biomimicry is? ◉ Yes ○ No

Are you aware of the Biomimicry Institute or Guild? ◉ Yes ○ No

If yes, do you have any personal experience working within the field (specifically design related)? ○ Yes ◉ No

If so, please explain:

Graphic Design + Biomimicry | User Survey 1



Resource Guidebook Success Determinants

After reading or looking through the Graphic Design + Biomimicry book, were you able to understand and grasp the following concepts: (Please fill in at least *one* circle for each)

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• What biomimicry is?	◉	○	○
• How to apply the six stages of the process to a real-world design scenario?	◉	○	○
• How to integrate biomimetic design into corporations and creative sessions?	◉	○	○
• How to take Nature's 14 Design principles and apply them to your process?	○	◉	○
• How the methodologies of graphic design + biomimicry integrate to form this process?	◉	○	○
• How the Sierpinski triangle and fractal patterns are applied to the process?	○	◉	○
• How to use natural algorithms to create tessellation patterns?	◉	○	○
• What materials and tools you should use in biomimetic design?	◉	○	○
• How nature can play a positive role nature within modern design practices?	◉	○	○
• Did the icons, charts, infographics, and diagrams help?	◉	○	○
• Did you find the resources and case studies to be useful?	◉	○	○
• Were the two system solutions helpful and necessary?	◉	○	○

Do you think the Graphic Design + Biomimicry Resource Guidebook is successful? ◉ Yes ○ No

Was the overall design of the book appropriate and aesthetically pleasing? ◉ Yes ○ No

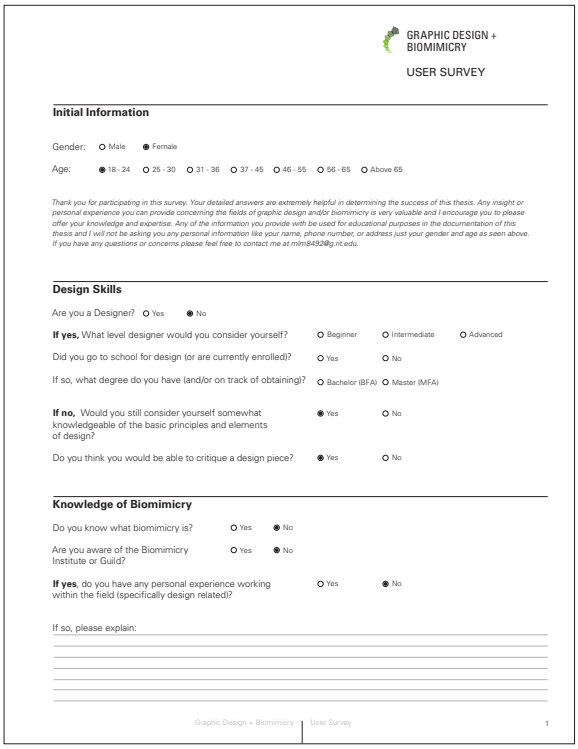
Did the design and layout of the book make it easier to comprehend? ◉ Yes ○ No

Please list any improvements that could be made:
Looks great!

Comments Overall:
I knew what biomimicry was prior to reading this book but did not really have any design knowledge. I now feel that I have a good understanding of the principles of both and how the two disciplines can be integrated. Overall, I think the book is very professional and a great example of good design based on what I see in stores and have read before. Good job!!

Graphic Design + Biomimicry | User Survey 2

User 11



GRAPHIC DESIGN + BIOMIMICRY

USER SURVEY

Initial Information

Gender: ○ Male ◉ Female

Age: ◉ 18 - 24 ○ 25 - 30 ○ 31 - 36 ○ 37 - 45 ○ 46 - 55 ○ 56 - 65 ○ Above 65

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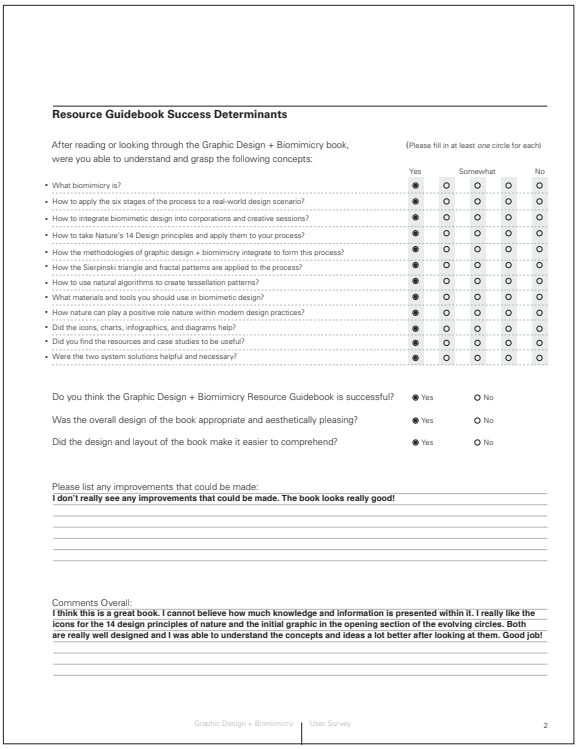
If so, please explain:

Graphic Design + Biomimicry | User Survey 1



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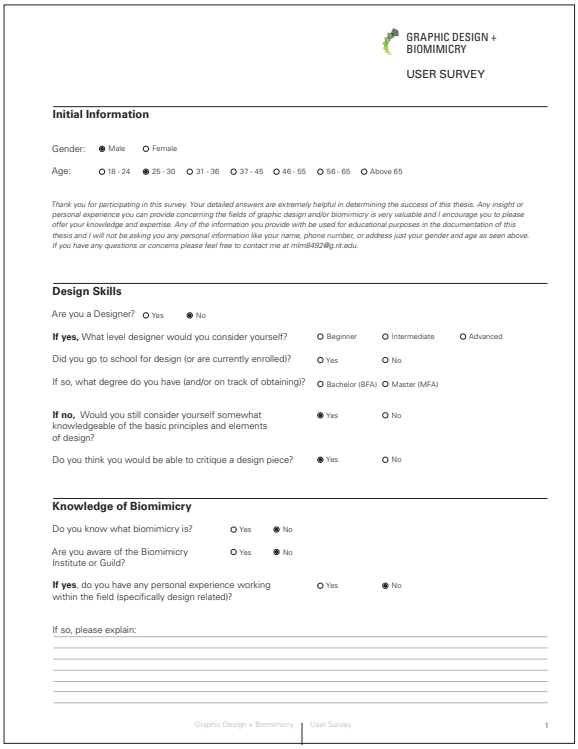
Did the design and layout of the book make it easier to comprehend? ◉ Yes ○ No

Please list any improvements that could be made:
I don't really see any improvements that could be made. The book looks really good!

Comments Overall:
I think this is a great book. I cannot believe how much knowledge and information is presented within it. I really like the icons for the 14 design principles of nature and the initial graphic in the opening section of the evolving circles. Both are really well designed and I was able to understand the concepts and ideas a lot better after looking at them. Good job!

Graphic Design + Biomimicry | User Survey 2

User 12



GRAPHIC DESIGN + BIOMIMICRY

USER SURVEY

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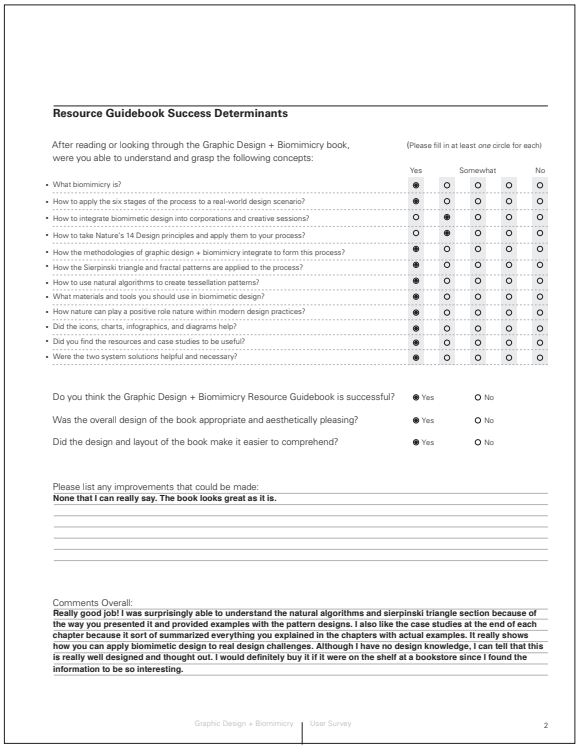

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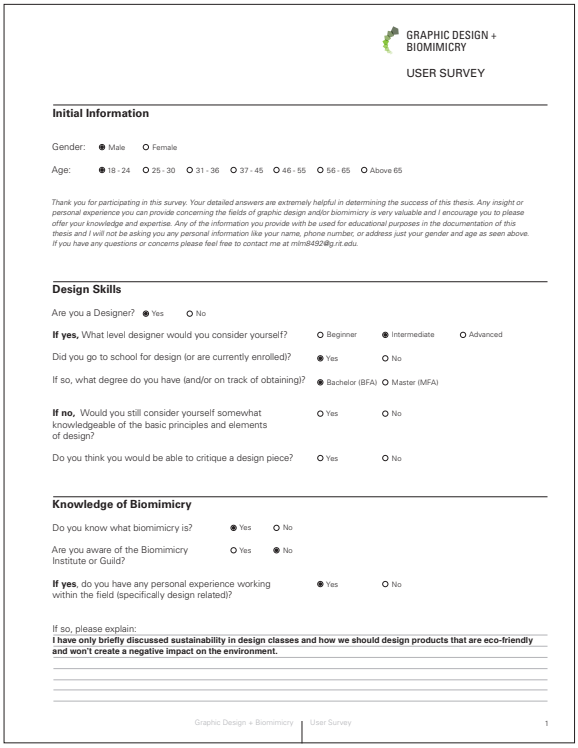
Please list any improvements that could be made:

None that I can really say. The book looks great as it is.

Comments Overall:

Really good job! I was surprisingly able to understand the natural algorithms and sierpinski triangle section because of the way you presented it and provided examples with the pattern designs. I also like the case studies at the end of each chapter because it sort of summarized everything you explained in the chapters with actual examples. It really shows how you can apply biomimetic design to real design challenges. Although I have no design knowledge, I can tell that this is really well designed and thought out. I would definitely buy it if it were on the shelf at a bookstore since I found the information to be so interesting.

User 13



GRAPHIC DESIGN + BIOMIMICRY

USER SURVEY

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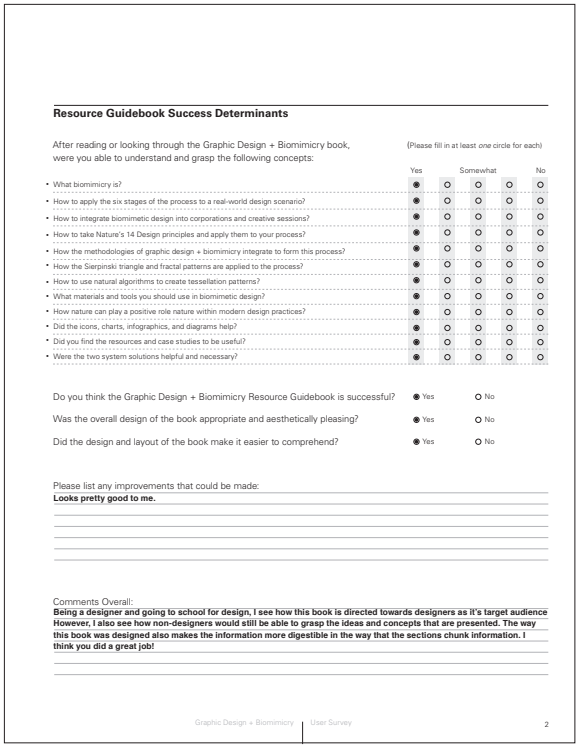
Are you aware of the Biomimicry Institute or Guild? ○ Yes ● No

If yes, do you have any personal experience working within the field (specifically design related)? ● Yes ○ No

If so, please explain:

I have only briefly discussed sustainability in design classes and how we should design products that are eco-friendly and won't create a negative impact on the environment.



Resource Guidebook Success Determinants

After reading or looking through the Graphic Design + Biomimicry book, were you able to understand and grasp the following concepts:

(Please fill in at least *one* circle for each)

	Yes	Somewhat	No
• What biomimicry is?	●	○	○
• How to apply the six stages of the process to a real-world design scenario?	●	○	○
• How to integrate biomimetic design into corporations and creative sessions?	●	○	○
• How to take Nature's 14 Design principles and apply them to your process?	●	○	○
• How the methodologies of graphic design + biomimicry integrate to form this process?	●	○	○
• How the Sierpinski triangle and fractal patterns are applied to the process?	●	○	○
• How to use natural algorithms to create tessellation patterns?	●	○	○
• What materials and tools you should use in biomimetic design?	●	○	○
• How nature can play a positive role nature within modern design practices?	●	○	○
• Did the icons, charts, infographics, and diagrams help?	●	○	○
• Did you find the resources and case studies to be useful?	●	○	○
• Were the two system solutions helpful and necessary?	●	○	○

Do you think the Graphic Design + Biomimicry Resource Guidebook is successful? ● Yes ○ No

Was the overall design of the book appropriate and aesthetically pleasing? ● Yes ○ No

Did the design and layout of the book make it easier to comprehend? ● Yes ○ No

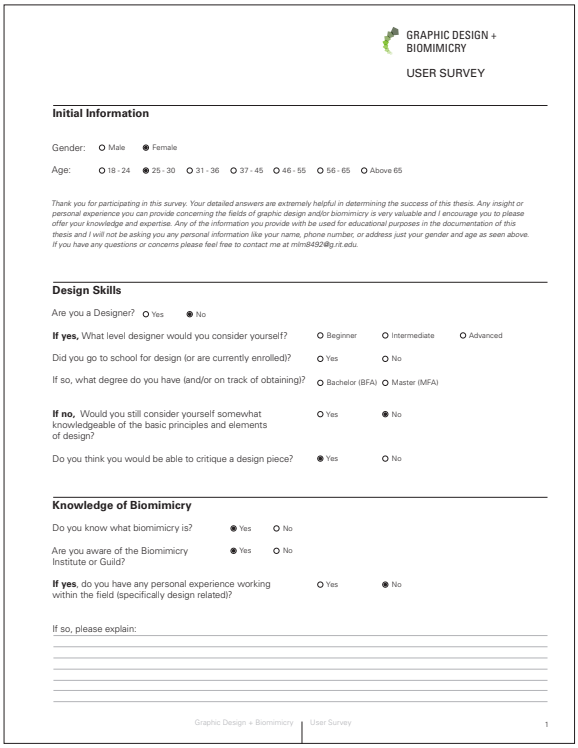
Please list any improvements that could be made:

Looks pretty good to me.

Comments Overall:

Being a designer and going to school for design, I see how this book is directed towards designers as it's target audience However, I also see how non-designers would still be able to grasp the ideas and concepts that are presented. The way this book was designed also makes the information more digestible in the way that the sections chunk information. I think you did a great job!

User 14



GRAPHIC DESIGN + BIOMIMICRY

USER SURVEY

Initial Information

Gender: ○ Male ◉ Female

Age: ○ 18 - 24 ◉ 25 - 30 ○ 31 - 36 ○ 37 - 45 ○ 46 - 55 ○ 56 - 65 ○ Above 65

Thank you for participating in this survey. Your detailed answers are extremely helpful in determining the success of this thesis. Any insight or personal experience you can provide concerning the fields of graphic design and/or biomimicry is very valuable and I encourage you to please offer your knowledge and expertise. Any of the information you provide with be used for educational purposes in the documentation of this thesis and I will not be asking you any personal information like your name, phone number, or address just your gender and age as seen above. If you have any questions or concerns please feel free to contact me at mlm8492@g.rit.edu.

Design Skills

Are you a Designer? ○ Yes ◉ No

If yes, What level designer would you consider yourself? ○ Beginner ○ Intermediate ○ Advanced

Did you go to school for design (or are currently enrolled)? ○ Yes ○ No

If so, what degree do you have (and/or on track of obtaining)? ○ Bachelor (BFA) ○ Master (MFA)

If no, Would you still consider yourself somewhat knowledgeable of the basic principles and elements of design? ○ Yes ◉ No

Do you think you would be able to critique a design piece? ◉ Yes ○ No

Knowledge of Biomimicry

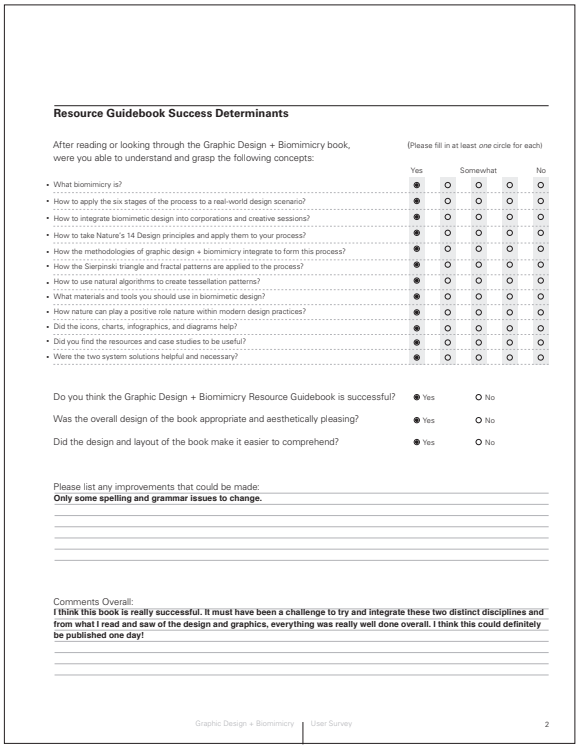
Do you know what biomimicry is? ◉ Yes ○ No

Are you aware of the Biomimicry Institute or Guild? ◉ Yes ○ No

If yes, do you have any personal experience working within the field (specifically design related)? ○ Yes ◉ No

If so, please explain:

Graphic Design + Biomimicry | User Survey 1



Resource Guidebook Success Determinants

After reading or looking through the Graphic Design + Biomimicry book, were you able to understand and grasp the following concepts: (Please fill in at least one circle for each)

	Yes		Somewhat		No
• What biomimicry is?	◉	○	○	○	○
• How to apply the six stages of the process to a real-world design scenario?	◉	○	○	○	○
• How to integrate biomimetic design into corporations and creative sessions?	◉	○	○	○	○
• How to take Nature's 14 Design principles and apply them to your process?	◉	○	○	○	○
• How the methodologies of graphic design + biomimicry integrate to form this process?	◉	○	○	○	○
• How the Sierpinski triangle and fractal patterns are applied to the process?	◉	○	○	○	○
• How to use natural algorithms to create tessellation patterns?	◉	○	○	○	○
• What materials and tools you should use in biomimetic design?	◉	○	○	○	○
• How nature can play a positive role nature within modern design practices?	◉	○	○	○	○
• Did the icons, charts, infographics, and diagrams help?	◉	○	○	○	○
• Did you find the resources and case studies to be useful?	◉	○	○	○	○
• Were the two system solutions helpful and necessary?	◉	○	○	○	○

Do you think the Graphic Design + Biomimicry Resource Guidebook is successful? ◉ Yes ○ No

Was the overall design of the book appropriate and aesthetically pleasing? ◉ Yes ○ No

Did the design and layout of the book make it easier to comprehend? ◉ Yes ○ No

Please list any improvements that could be made:

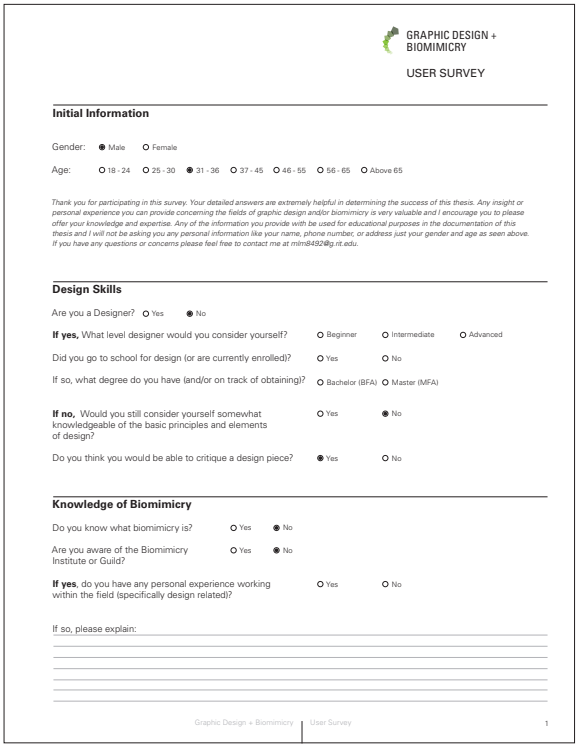
Only some spelling and grammar issues to change.

Comments Overall:

I think this book is really successful. It must have been a challenge to try and integrate these two distinct disciplines and from what I read and saw of the design and graphics, everything was really well done overall. I think this could definitely be published one day!

Graphic Design + Biomimicry | User Survey 2

User 15



GRAPHIC DESIGN + BIOMIMICRY

USER SURVEY

Initial Information

Gender: ◉ Male ○ Female

Age: ○ 18 - 24 ○ 25 - 30 ◉ 31 - 36 ○ 37 - 45 ○ 46 - 55 ○ 56 - 65 ○ Above 65

Thank you for participating in this survey. Your detailed answers are extremely helpful in determining the success of this thesis. Any insight or personal experience you can provide concerning the fields of graphic design and/or biomimicry is very valuable and I encourage you to please offer your knowledge and expertise. Any of the information you provide with be used for educational purposes in the documentation of this thesis and I will not be asking you any personal information like your name, phone number, or address just your gender and age as seen above. If you have any questions or concerns please feel free to contact me at mlm8492@g.rit.edu.

Design Skills

Are you a Designer? ○ Yes ◉ No

If yes, What level designer would you consider yourself? ○ Beginner ○ Intermediate ○ Advanced

Did you go to school for design (or are currently enrolled)? ○ Yes ○ No

If so, what degree do you have (and/or on track of obtaining)? ○ Bachelor (BFA) ○ Master (MFA)

If no, Would you still consider yourself somewhat knowledgeable of the basic principles and elements of design? ○ Yes ◉ No

Do you think you would be able to critique a design piece? ◉ Yes ○ No

Knowledge of Biomimicry

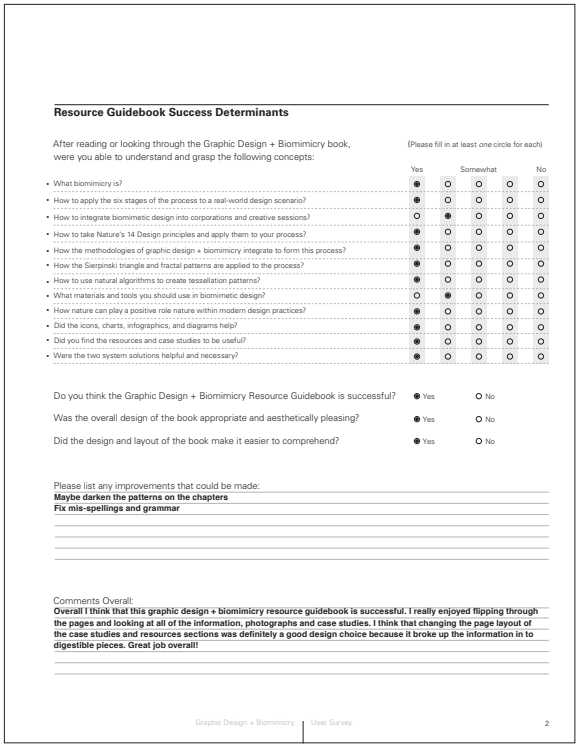
Do you know what biomimicry is? ○ Yes ◉ No

Are you aware of the Biomimicry Institute or Guild? ○ Yes ◉ No

If yes, do you have any personal experience working within the field (specifically design related)? ○ Yes ○ No

If so, please explain:

Graphic Design + Biomimicry | User Survey 1



Resource Guidebook Success Determinants

After reading or looking through the Graphic Design + Biomimicry book, were you able to understand and grasp the following concepts: (Please fill in at least one circle for each)

	Yes		Somewhat		No
• What biomimicry is?	◉	○	○	○	○
• How to apply the six stages of the process to a real-world design scenario?	◉	○	○	○	○
• How to integrate biomimetic design into corporations and creative sessions?	○	◉	○	○	○
• How to take Nature's 14 Design principles and apply them to your process?	◉	○	○	○	○
• How the methodologies of graphic design + biomimicry integrate to form this process?	◉	○	○	○	○
• How the Sierpinski triangle and fractal patterns are applied to the process?	◉	○	○	○	○
• How to use natural algorithms to create tessellation patterns?	◉	○	○	○	○
• What materials and tools you should use in biomimetic design?	○	◉	○	○	○
• How nature can play a positive role nature within modern design practices?	◉	○	○	○	○
• Did the icons, charts, infographics, and diagrams help?	◉	○	○	○	○
• Did you find the resources and case studies to be useful?	◉	○	○	○	○
• Were the two system solutions helpful and necessary?	◉	○	○	○	○

Do you think the Graphic Design + Biomimicry Resource Guidebook is successful? ◉ Yes ○ No

Was the overall design of the book appropriate and aesthetically pleasing? ◉ Yes ○ No

Did the design and layout of the book make it easier to comprehend? ◉ Yes ○ No

Please list any improvements that could be made:

Maybe darken the patterns on the chapters

Fix mis-spellings and grammar

Comments Overall:

Overall I think that this graphic design + biomimicry resource guidebook is successful. I really enjoyed flipping through the pages and looking at all of the information, photographs and case studies. I think that changing the page layout of the case studies and resources sections was definitely a good design choice because it broke up the information in to digestible pieces. Great job overall!

Graphic Design + Biomimicry | User Survey 2

Appendix 5 Email Documentation

Letter sent to Jessica Jones, a Graphic Designer and Visual Communicator at the Biomimicry Institute in Missoula, MT.

MARGARET MCKOSKY

GRAPHIC DESIGNER & PHOTOGRAPHER

6 January 2012

Jessica Jones
Biomimicry Institute
140 S 4th St W Suite B
Missoula, MT 59801

Dear Jessica,

My name is Margaret McKosky and I am currently a second year Graduate Graphic Design student at Rochester Institute of Technology. I am writing to you because I am very interested in biomimicry and how it can be incorporated into the field of graphic design. I am in the middle of researching and developing my thesis entitled '*What Would Nature Do?* Integrating Biomimicry + Graphic Design to Effectively Create an Innovative Design Process.' In examining the two distinct disciplines, my perspective is that biomimicry is a relatively new and unexplored area within the graphic design field; more commonly linked with Industrial Design. This is essentially what led me to my thesis topic and the desire to investigate the matter further. I believe that in taking the methodology of biomimicry and meshing it within the methodology of graphic design, it would produce an innovative hybrid of the two creating an alternate and revolutionary process based on nature's time-tested ideals and design guidelines. The challenge I am facing is how to take the designs nature has produced over the billions of years and echo them to produce effective, timeless, and sustainable solutions. As you may know, bringing biomimicry into the field of graphic design is rather different than exploring it within industrial or product design. Ultimately, it is my goal to institute a fresh mode of thinking forcing designers to innovate, experience, push and adapt their design solutions further than they ever have before. In the end, I am hoping my thesis will open designer's minds up to a new realm of possibilities and allow for them to truly appreciate the design guidelines nature has given us.

With that being said, I feel that I could use some assistance within my research of these two disciplines. I saw on the Biomimicry Institute's website that you are the Visual Naturalist involved with visual communications, strategy and branding. I was wondering if you could perhaps give me some insight as to how you yourself integrate graphic design with biomimicry into your graphic design process at the Institute? I would love to share ideas and would truly appreciate any thoughts you may have on this unique and inspiring topic. I look forward to hearing from you!

Sincerely,

Margaret McKosky

Thesis Website
http://maggiesgdthesis.weebly.com

Personal Website
www.margaretmckosky.com

email mckoskym@yahoo.com
mobile 716-479-5433
address 8295 Garrock Road
Williamsville, NY 14221

Response

Jessica Jones

Email correspondence on Wednesday, Jan 18, 2012 at 2:13 PM

To: Margaret McKosky <mckoskym@yahoo.com>

From: Jessica Jones <jessicaj@biomimicrygroup.com>

Cc: Andrea Leggitt<andreal@biomimicrygroup.com>

Subject: Biomimicry + Graphic Design

Hi Margaret,

Thank you for sending a letter to the Biomimicry 3.8 Institute and for your interest in biomimicry. You are correct that biomimicry as it relates to graphic design seems to be a relatively new and unexplored area so your thesis is timely and I'm sure will be very interesting. I would very much enjoy exchanging ideas. There is also another graphic designer here at Biomimicry 3.8, Andrea Leggitt, who I am sure has some ideas to share as well. Would you like to schedule a call with us to brainstorm and discuss how we have used biomimetic inspiration in our own work? Usually anytime Monday through Thursday between 12 and 4 Mountain time works well for us.

In the meantime, here are a few resources that may be of interest to you:

- AskNature.org
- AskNature.com discussion thread: http://asknature.org/forum/de3093cb4dc89c53b133236944fc1c8b
- I wrote an article about Biomimicry and Graphics Design found in this book: Sustainable Graphic Design: Tools, Systems and Strategies for Innovative Print Design by Wendy Jedlicka (Paperback - Mar 23, 2009)
- Throughout the years, I've been compiling examples of graphic designs that exemplify life's principles and functions but am only now organizing them into a blog for others to see. Also, on the blog will be an overview on biomimicry and graphics design. I'll share this url with you in the next couple of weeks.

We look forward to hearing from you,

Jessica and Andrea

°°°

JESSICA JONES

Visual Communicator | Biomimicry 3.8

+1 406 543 4108 x213 | +1 605 431 6160 mobile

Biomimicry.net | AskNature.org

Email correspondence on Friday, Jan 20, 2012 at 10:27 AM
To: Jessica Jones <jessicaj@biomimicrygroup.com>
From: Margaret McKosky <mckoskym@yahoo.com>
Cc: Andrea Leggitt<andreal@biomimicrygroup.com>
Subject: Biomimicry + Graphic Design

Hello Jessica,

Thank you for responding to my letter in such a timely fashion! I also wanted to thank you for the resources you provided me with; they will definitely help me with my research/documentation of my thesis. I am very much looking forward to your blog that you are currently working on and going to be putting up soon. I would love to schedule a call with you and Andrea to exchange ideas about our different processes and how we incorporate biomimicry into our own work. Mondays/Wednesdays work best for me, but let me know what day is the best for you and we can figure out a day/time that works!

Looking forward to speaking with the both of you,
Margaret

Email correspondence on Tuesday, Jan 24, 2012 at 10:34 AM
To: Margaret McKosky <mckoskym@yahoo.com>
From: Jessica Jones <jessicaj@biomimicrygroup.com>
Cc: Andrea Leggitt<andreal@biomimicrygroup.com>
Subject: Biomimicry + Graphic Design

Margaret,
Wednesday February 1st at 12:00 pm Mountain time works well for us. Let us know if that works for you. Or if you meet sooner to get your thesis moving along, let us know and we could probably find a time to talk tomorrow.

There are a few options for calling:

- we could use skype; if you have an account just give us your skype name (mine is goldenratiojess)
- you could call us at 406 543 4108 Ext 400
- we could call you (just give us your phone number)

Jessica and Andrea

Email correspondence on Wednesday, Jan 25, 2012 at 07:11 AM
To: Jessica Jones <jessicaj@biomimicrygroup.com>
From: Margaret McKosky <mckoskym@yahoo.com>
Cc: Andrea Leggitt<andreal@biomimicrygroup.com>
Subject: Biomimicry + Graphic Design

Jessica & Andrea,

Wednesday February 1st at 12:00 pm Mountain time works for me. If you wouldn't mind calling me on my cell at (716) 479-5433; I think that would be best. I'm really looking forward to discussing and exchanging ideas with the both of you!

Have a good day,
Margaret

Email correspondence on Tuesday, Jan 24, 2012 at 10:34 AM
To: Margaret McKosky <mckoskym@yahoo.com>
From: Jessica Jones <jessicaj@biomimicrygroup.com>
Cc: Andrea Leggitt<andreal@biomimicrygroup.com>
Subject: Biomimicry + Graphic Design

Margaret,
Okay, it's on our calendars and we will call you at the number provided. Talk to you next week!

Jessica and Andrea

°°°

JESSICA JONES
Visual Communicator | Biomimicry 3.8
+1 406 543 4108 x213 | +1 605 431 6160 mobile
Biomimicry.net | AskNature.org

Email correspondence on Wednesday, Jan 11, 2012 at 09:59 AM
To: Designers Accord <join@designersaccord.org>
From: Margaret McKosky <mckoskym@yahoo.com>
Subject: Becoming a Supporter

To whom it may concern,

My name is Margaret McKosky and I am currently a second year Graduate Graphic Design student at Rochester Institute of Technology. I am writing to you because I am very interested in becoming a supporter of the The Designers Accord. I believe that design has the power to generate significant change in regards to creating positive environmental and social impact and ultimately it is why I do what I do. As designers, we are problem solvers. We apply our creative talents to finding new and appropriate innovative solutions to common questions. These questions include how to best articulate a brand, how to connect with a particular audience or how to communicate across cultural boundaries. Now more than ever, there are bigger problems than just brands and connecting to consumers. There are fundamental needs such as equality, education, food, water, community, peace, justice, and hope. It is instrumental that designers constantly ask themselves, what is my responsibility? How am I affecting or bettering the world I reside in? Once designers ask themselves these questions, they come to the realization that their work has the potential to both be good and do good.

Currently I am in the middle of researching and developing my thesis entitled 'What Would Nature Do? Integrating Biomimicry + Graphic Design to Effectively Create an Innovative Design Process.' I am very interested in biomimicry and how it can be incorporated into the field of graphic design. In examining the two distinct disciplines, my perspective is that biomimicry is a relatively new and unexplored area within the graphic design field; more commonly linked with Industrial Design. This is essentially what led me to my thesis topic and the desire to investigate the matter further. I believe that in taking the methodology of biomimicry and meshing it within the methodology of graphic design, it would produce an innovative hybrid of the two creating an alternate and revolutionary process based on nature's time-tested ideals and design guidelines. In using nature as inspiration throughout the design process, it will allow for designers to think about the many facets their solution is going to be applied to. For instance, how will my design affect the environment, will my design be sustainable, how will people interpret or use this design solution, and how will this solution stand the test of time?

The challenge I am facing is how to take the designs nature has produced over the billions of years and echo them to produce effective, timeless, and sustainable solutions. Ultimately, it is my goal to institute a fresh mode of thinking forcing designers to innovate, experience, push and adapt their design solutions further than they ever have before. In the end, I am hoping my thesis will open designer's minds up to a new realm of possibilities and allow for them to truly appreciate the design guidelines nature has given us.

With that being said, I believe I am a strong advocator and supporter of creating sustainable design that makes a positive social and environmental impact. As a graphic designer that is soon going to be immersed within the design industry upon graduating from RIT this upcoming May 2012, I am sure that I will continue down the path of promoting the power design holds in generating social and environmental change for the better.

Sincerely,
Margaret McKosky

- Student at Rochester Institute of Technology
- Residing in Buffalo, NY
- Personal Website | www.margaretmckosky.com
- Email | mckoskym@yahoo.com
- RIT Gmail | mlm8492@g.rit.edu

Email correspondence on Thursday, Jan 19, 2012 at 03:34 PM
To: Margaret McKosky <mckoskym@yahoo.com>
From: Join The Designers Accord <join@designersaccord.org>
Subject: Re: Becoming a Supporter

Hi Maggie:

Thanks for your interest in The Designers Accord. Your thesis sounds very intriguing...definitely keep us posted on your progress. In the meantime we'll add you our ever-growing network of designers, educators, and business leaders working together to create positive impact.

Be sure to check out the website for new projects and events: www.designersaccord.org and our Education Toolkit for integrating sustainability in design education: edutoolkit.designersaccord.org

And follow us on twitter for a continuous stream of information and provocation: @designersaccord

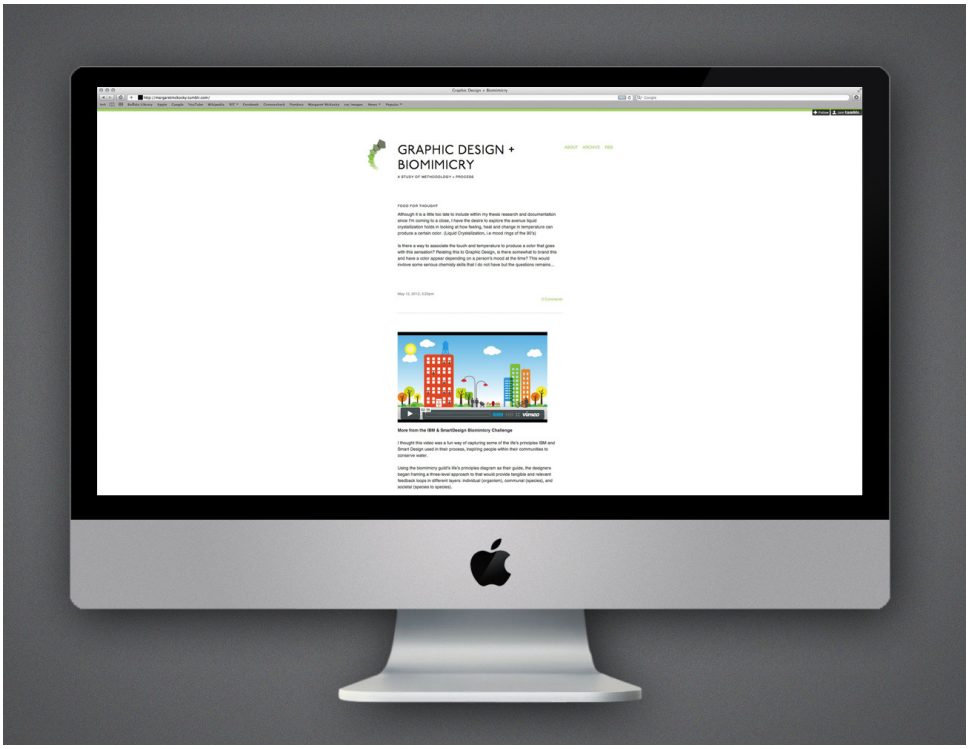
Best Regards and Happy New Year,

Olivia
The Designers Accord

Appendix 6 Blog Documentation

In order to share my progress and document my research and findings throughout my thesis process, I thought it was appropriate to set up a blog.

Thesis Blog: http://margaretmckosky.tumblr.com/



Posts

Earliest to Most Recent

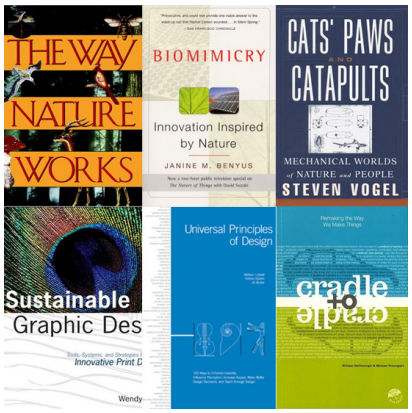
WELCOME

Hello everyone! I am very excited to be writing my first post on my new blog!…As some of you may know, I am currently in the research/documentation phase of my thesis and I am happy to say that I am making significant progress! However, as I am finding and developing more and more, I felt that I needed a better place to share my research, findings, and ideas…so, why not start a blog?!

From here on out, I will be using this personal blog to show my work/progress and hopefully once my thesis is published come May (crossing my fingers), I will continue to post weekly to share my thoughts on the exciting topic of Biomimicry + Design.

*Note: I am going to be posting a lot of my previous work in the next couple of days for documentation purposes (some of you may have already seen some of this before), so please bare with me!

February 17, 2012, 5:05pm



February 19, 2012, 4:03pm

Above are just a few of the books I have read and looked through as a part of my research documentation. The two books that I am most inspired by are Janine Benyus's book, Innovation Inspired by Nature, and Wendy Jedlicka's Sustainable Graphic Design…I plan on reading both of them over and over again until I have absorbed as much as I can! I highly recommend them if you are interested in biomimicry, sustainability, and design. I have also researched books in other academic areas, such as our psyche/how we think and interpret information, graphic design theory, color theory and experimental layouts that will be helpful for my Graphic Design Resource Guide Book.

"Life's design brief is simple. Learn how to create and make things while creating conditions conducive to life on earth."

Janine Benyus

TED Talks | Biomimicry in Action | Feb 2005

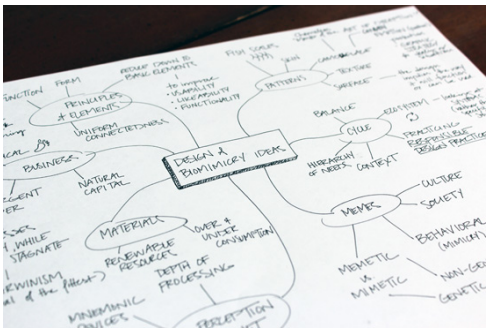
February 27, 2012, 4:10pm

February 28, 2012, 12:36pm

Super Chameleon…extreme camouflaging is amazing

This led me to brainstorm the idea of: How can Biomimicry inspire graphic design in terms of patterns, textures & color theory? Creating patterns with specific colors that evoke a particular emotion/pathos?

Surface Mimicry: coming up with a graphic strategy for dealing with situations…the art of deception

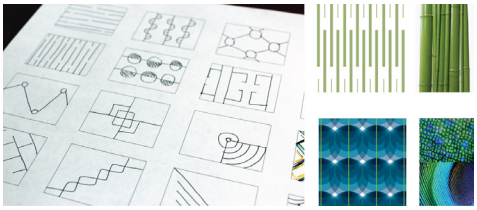


February 28, 2012, 2:43pm

Mind Mapping

I want to explore many areas of graphic design and biomimicry within my GD Resource & Guidebook. However, in order to show the scope of my research without showing too much, I need to narrow the areas down to the simplest and best solutions. Of course, keeping in mind the end goal of demonstrating how the methodologies of both graphic design & biomimicry integrate to form an innovative process and system. As of right now, I am going to focus on the following chapters…

- Patterns | Form | Function (Develop Graphic Solution & Case Studies)
- Awareness (What is Biomimicry and How can it be incorporated into the Design Industry)
- Life's Principles & Design Elements (Diagram Showing Design Cycle and System)
- Materials (Over & Under Consumption of Resources, Case Studies)
- Business (Improving Creative Brainstorming Sessions & Reducing Our Ecological Footprint)
- Perception & Mindset (Changing Our Perception & How we Think, Depth of Processing)



Pattern Design Inspired by Camouflage (Surface Mimicry)

Some quick sketches/development of pattern designs I am going to create inspired by surface mimicry and intervals found within nature.

February 28, 2012, 4:05pm

"Biomimicry focuses on finding structures, processes, strategies, and mechanisms that nature has been using for a billion of years, that we can emulate and use in modern design."
Terry Tempest Williams
(American author, conservationist, and activist)

February 28, 2012, 5:38pm

Shapeshifting Biomimic Octopus

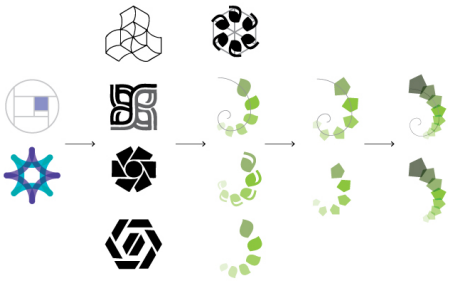
(Complements of Shaun & Committee, Thank you!)

March 08, 2012, 12:11pm

Tessellation Patterns

This is part of my research on patterns and surface mimicry… looking into how using joined and fit polygons can create a continuous, unique pattern design (similar to mosaic tiling) and how it can relate to the surface mimicry of animals. The process is taking a polygon and repeating it throughout to create a grid-like pattern. The images seen are a combination of animal skins and other elements of nature.

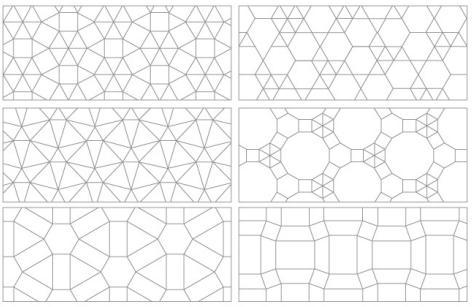
April 19, 2012, 3:15pm



Logo Identity Process

I've been struggling to come up with an identity for my thesis and Graphic Design + Biomimicry process…I am trying to incorporate the organic sensibility as well as the geometrical/ mathematical side based off of the golden ratio grid. For now I am going with the one on the farthest right but it is still a work in progress!

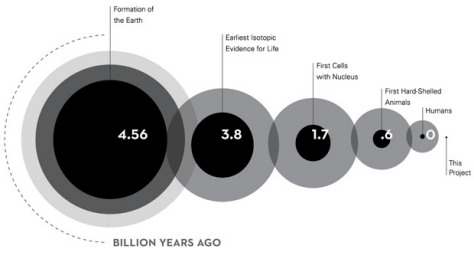
April 20, 2012, 12:08pm



Tessellation Grid Patterns

The other grid patterns I designed inspired by animal skins, geometric ratios and proportions as well as fractal patterning. I am going to apply images inside each polygon shape like I did with the giraffe inspired-brown hue one seen below (these patterns will be in the surface mimicry section of my book)

April 20, 2012, 12:20pm



Infographic

I created this infographic to include within the introduction of my book. It is meant to defend my thesis in showing how organisms and their ecosystems have been existing on this planet for 3.8 billion years and know better than we do since humans (homo sapiens) have only been here for a very short amount of time.

The 'this project' aspect is a touch of humor :)

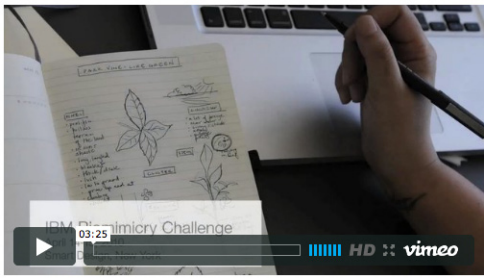
April 20, 2012, 12:26pm

DEFINITIONS

Zeitgeber: environmental cue as the length of daylight or the degree of temperature, that helps to regulate the cycles of an organism's biological clock

Meme: an element of a culture or system of behavior that may be considered to be passed from one individual to another by non-genetic means, esp. imitation

April 24, 2012, 1:26pm



April 25, 2012, 10:19am

IBM Biomimicry Challenge

It is always inspiring to see world-class companies adopting the biomimetic mind-set and process within their creative brainstorming sessions; using nature's principles to solve their design problem in a way that will not only be beneficial for the eco-system and environment, but for their company as well.

This video is about IBM's SmarterCity Initiative, a program that uses the company's information technology to help municipal governments create healthier, more intelligent urban environments for their residents. Using their ability to collect and analyze data, IBM is able to provide information about elements of daily city life ranging from weather and traffic to water usage and air quality. But what they've done with that data has largely been used to make policy and economic decisions. IBM decided to look to biomimicry, asking how they could use nature to understand how these overlays of information could help guide residents toward making better personal decisions for the good of the city. A New York-based team at SmartDesign accepted their challenge. This video is an interview with Tucker Fort, a member of the design team.

If you want to learn more about this design challenge, click the link below…http://www.fastcompany.com/1648801/biomimicry-challenge-smart-design-ecosystem-approach-to-water-conservation-for-ibm

April 25, 2012, 2:24pm

IDEO and the USGBC

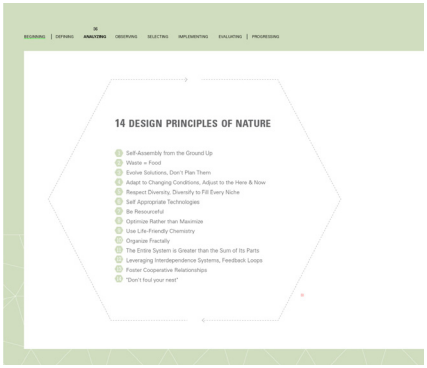
This is another case study I found that shows an example of biomimicry being integrated into the design process to help improve communication within a corporation (will be using as a case study within the business section of my guidebook)

It explores how nature can inspire improved communication processes within the USGBC (The United States Green Building Council- who most notably founded the LEED certification system that rates structures by sustainability). My favorite element within this case study is the timeline showing the biomimicry + design process they followed (see above). The highlights are:

- Design – researching the "users" and understanding the context of the challenge
- Before jumping to solutions, bio-inspiration is presented to the group according to the previous insights. Inspiration included organisms, but were presented in the deeper context of life's principles; i.e. "why" should we look at this organism
- Playful, challenging, broad ideation, connecting all the inspiration and insights into a variety of ideas
- Simple, clear communication of final insights

The reason why I think this is an excellent case study integrating biomimicry + the design process in business is to highlight the conversation of life's principles within the biology research stage. Without the life's principles it is easy to get excited about an aspect of the organism, but the deeper principles reminds designers that the organism is part of a larger, inter-connected eco-system. It pushes whatever design ideas are developed to also be connected at a broader systems level, leveraging interdependence systems and feedback loops.

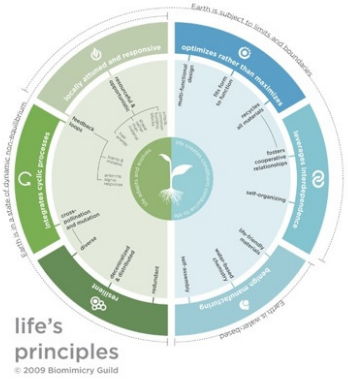
If you want to know more about the design challenge, click the link below…http://www.fastcompany.com/1643489/bio-mimicry-challenge-ideo-uses-nature-to-reorganize-the-usgbc



April 25, 2012, 2:32pm

14 Design Principles of Nature

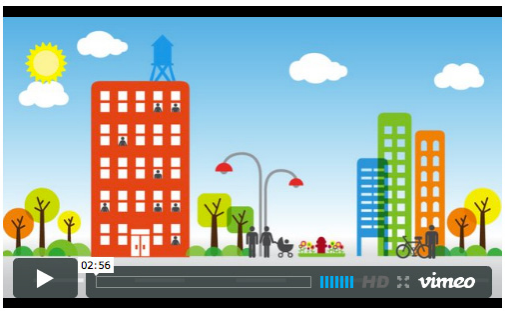
Above is a page from the reference book I am working on. The principles are a distilled combination of those life's principles enumerated by the Biomimicry Institute and Janine Benyus, Michael Braungart and William McDonough (authors of Cradle to Cradle), Steven Vogel (author of Cats' Paws and Catapults), D' Arcy Thompson (author of On Growth and Form), Julian Vincent (author of Structural Biomaterials), Jeremy Fauldi (sustainable design strategist and researcher, articles for Worldchanging.com) and my own limited experience of knowledge and research on the subject of biomimetic design. This is the indirect method of beginning to apply the two methodologies;biomimicry into graphic design, using abstracted principles of how nature designs.



April 25, 2012, 2:36pm

Life's Principles Diagram by the Biomimicry Guild

Life's principles are the deep principles of nature that fuel and inspire deep sustainability, or whatever is beyond that concept. These principles are present in all organisms at multiple scales and levels and capture the strategies that life has used to thrive on this planet and have applications to all types of design including all stages of the graphic design and visual communication process.



April 25, 2012, 3:08pm

More from the IBM & SmartDesign Biomimicry Challenge

I thought this video was a fun way of capturing some of the life's principles IBM and Smart Design used in their process, inspiring people within their communities to conserve water.

Using the biomimicry guild's life's principles diagram as their guide, the designers began framing a three-level approach to that would provide tangible and relevant feedback loops in different layers: individual (organism), communal (species), and societal (species to species).

FOOD FOR THOUGHT

Although it is a little too late to include within my thesis research and documentation since I'm coming to a close, I have the desire to explore the avenue liquid crystallization holds in looking at how feeling, heat and change in temperature can produce a certain color. (Liquid Crystallization, i.e mood rings of the 90's)

Is there a way to associate the touch and temperature to produce a color that goes with this sensation? Relating this to Graphic Design, is there somewhat to brand this and have a color appear depending on a person's mood at the time? This would involve some serious chemistry skills that I do not have but the questions remains…

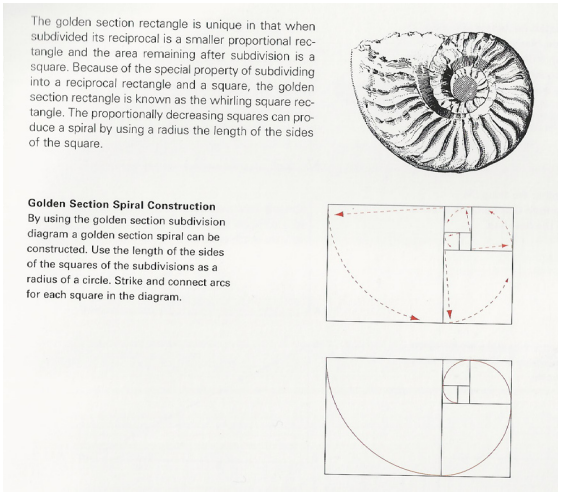
April 25, 2012, 2:36pm

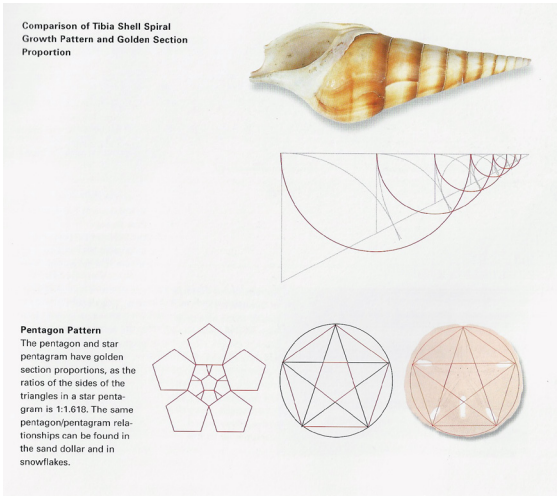
Appendix 7 Diagrams & Ideation

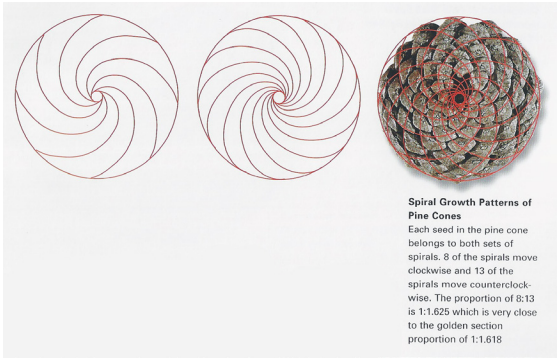
The following diagrams are taken from various book and online sources that were used in the ideation and research phase of my thesis process.

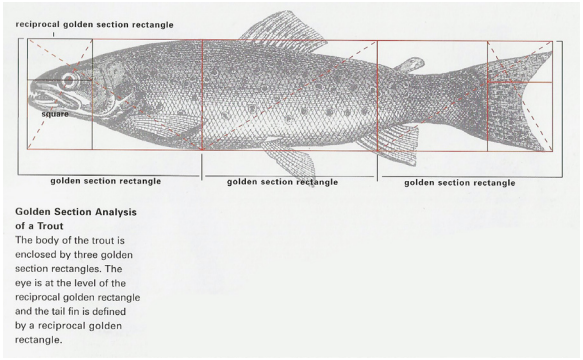
Geometry of Design by Kimberly Elam

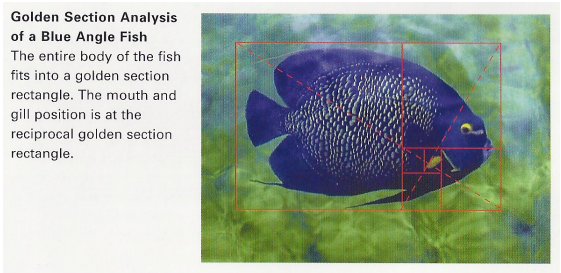
Research of Natural Proportion Systems, Spiral Growth Patterns, and Ratios

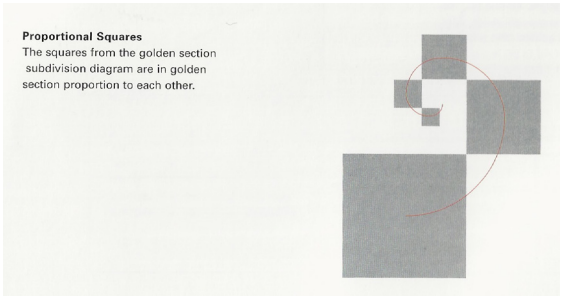


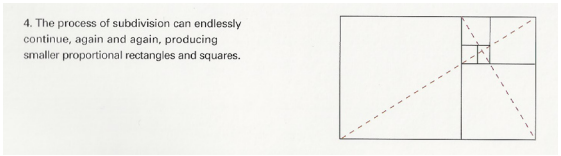


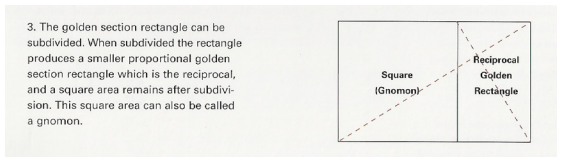






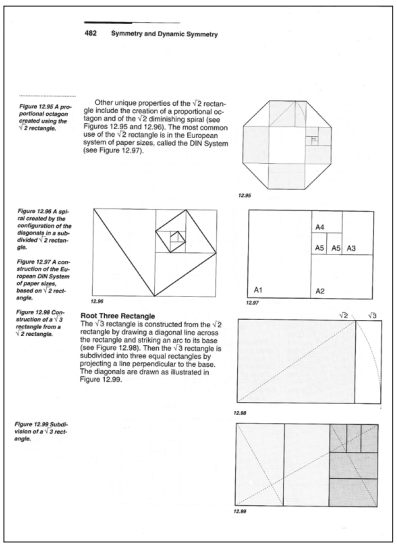


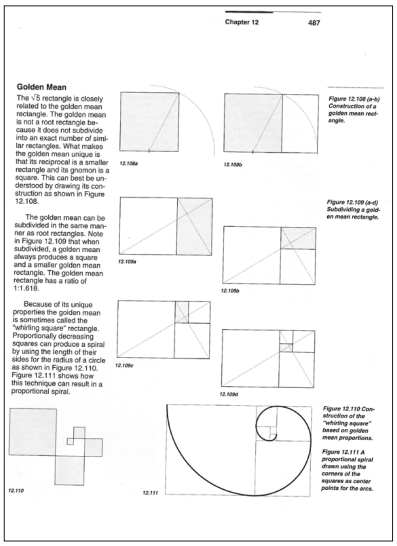


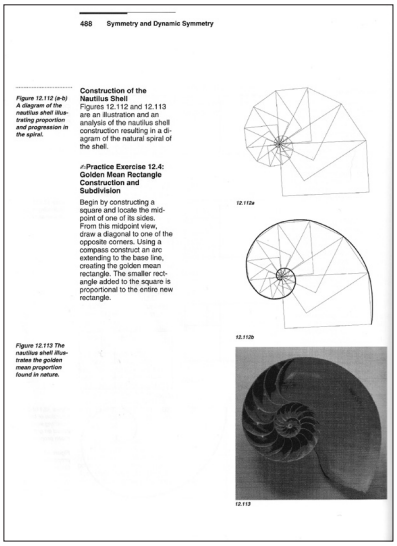


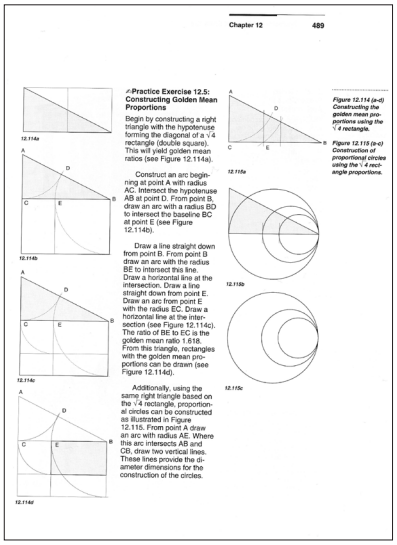
Basic Visual Concepts and Principles for Artists by Charles Wallschlaeger & Cynthia Busic-Snyder

Research of Natural Proportion Systems and Ratios



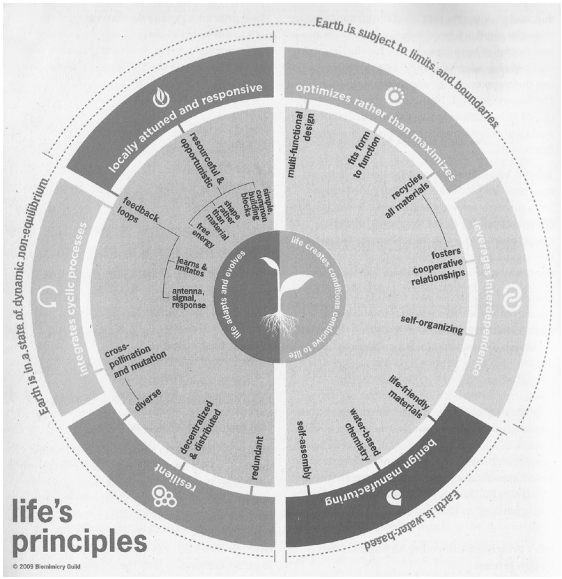






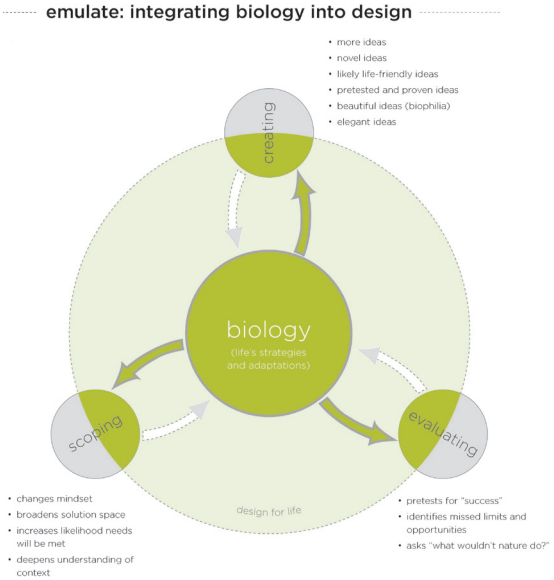
Life's Principles Diagram by The Biomimicry Guild

Research of Nature's Design Principles

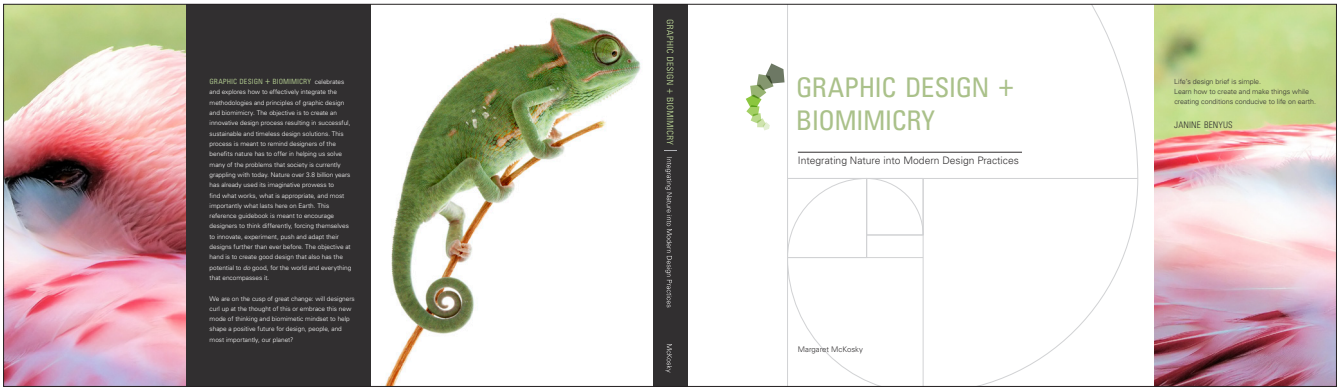


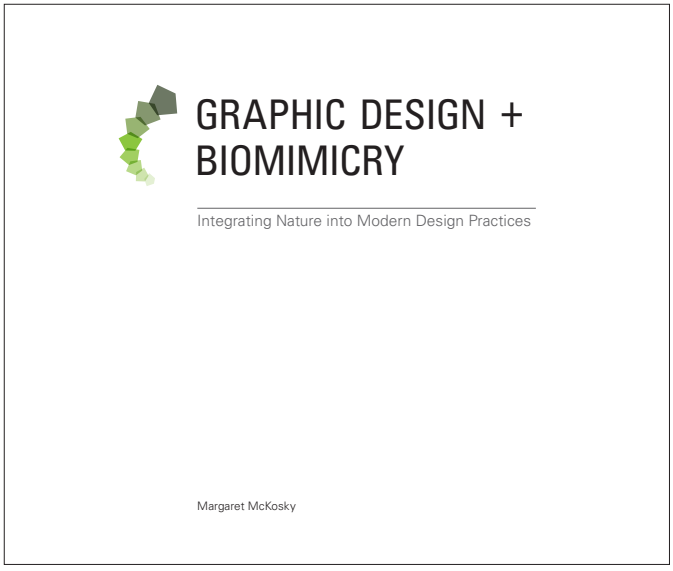
Integrating Biology into Design Diagram by The Biomimicry Guild

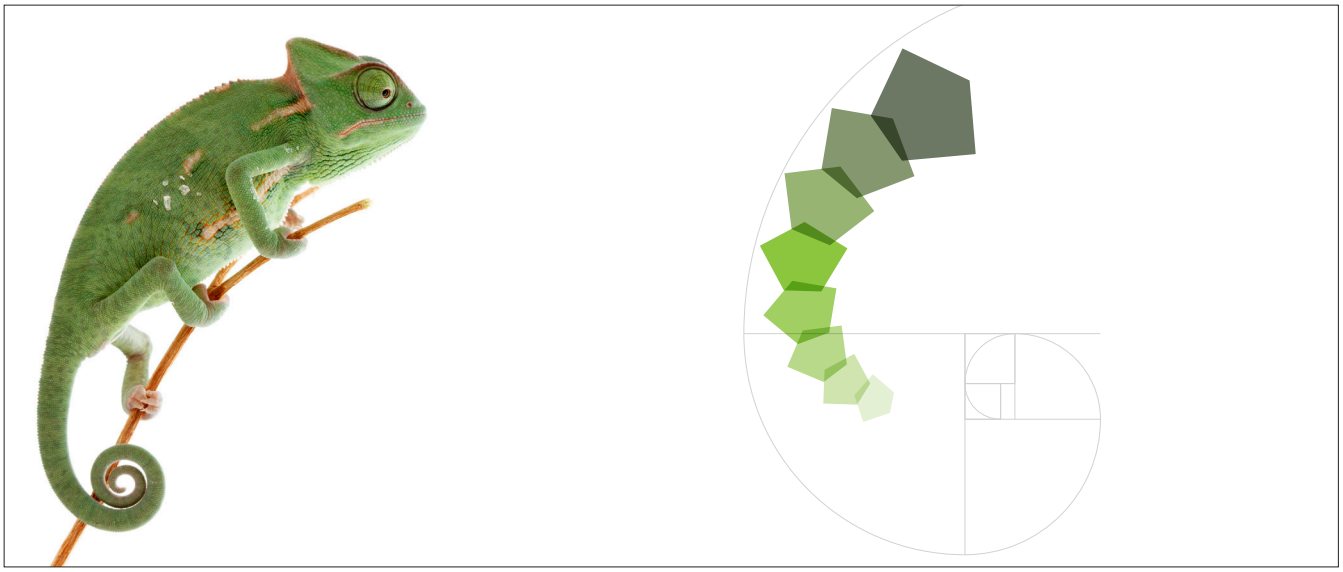
Research of Integrating the two Methodologies



Appendix 8 Large Final Application







GRAPHIC DESIGN + BIOMIMICRY

Printed and bound by Blurb,
http://www.blurb.com/

This project was produced with support from Rochester Institute of Technology, College of Imaging Arts and Science, School of Design.

This book is the final print application, documenting all of the research done for this thesis project prior to attaining a Masters of Fine Arts Degree. It is intended for educational purposes only. Every effort has been made to ensure that credits accurately comply with the information supplied. I apologize for any inaccuracies that may have occurred and will resolve inaccurate or missing information in a subsequent re-editing and printing of the book.

ACKNOWLEDGEMENTS

This book would not have been possible nor nearly as good without the talent, contribution and support of the following people who graciously committed their time to help guide me through. Also, a special thanks to the organizations that inspire me everyday.

Nancy Ciolek, Lorrie Frear, and Josh Owen
my wonderful and brilliant committee members

Jessica Jones and Andrea Leggitt
for taking the time to speak with me and allowing me to use their knowledge and research

Biomimicry 3.8
for inspiring me to do this book

The Designers Accord
for encouraging me to share this project

Rochester Institute of Technology
for supplying me with knowledge and opportunities

My Family & Friends
whose patience, love and support sustain all efforts, but were especially tested on this one

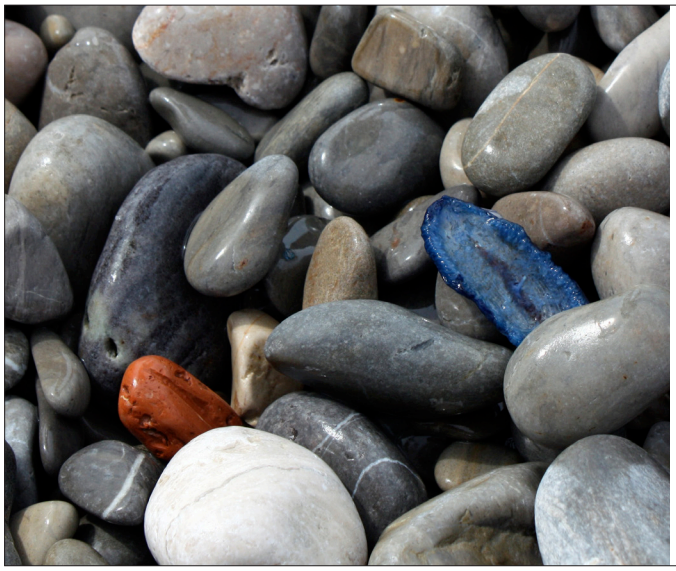
Bi•o•mim•ic•ry

(noun)
the design and production of materials, structures, and systems that are modeled after biological entities and processes[1]

from the Greek bios, life, mimesis, imitation

[1] New Oxford American Dictionary 3rd ed © 2010

CONTENTS



BEGINNING

Situation Analysis

[1] Janine Benyus, *Biomimicry: Innovation Inspired by Nature*

[2] For a detailed discussion of Janine Benyus's thoughts on Biomimicry, visit TED Talks at www.ted.com

[3] For more information on Biomimicry, visit http://www.biomimicryinstitute.org/

Biomimicry is a relatively new discipline that studies nature's finest ideas and then attempts to imitate these designs and processes to solve human problems. It is simply innovation inspired by nature,[1] or as Janine Benyus, one of the leading researchers of biomimicry today, would say it is the 'conscious emulation of life's genius on the path to a sustainable future.'[2] The core concept is that nature over 3.8 billion years has already used its imaginative prowess to solve many of the problems that society is currently grappling with today. Nature has found what works, what is appropriate, and most importantly, what lasts here on Earth.

That said, life found within nature is the secret to survival and the area to which we should be seeking the answers to our problems. In order to emulate nature's genius and reflect it onto our existing world, we must view nature in an entirely different manner. As the Biomimicry Guild and Institute believes, we need to look at nature as model, measure, and mentor.[3] The Guild and its collaborators have developed a specific practical design tool called the Biomimicry Design Spiral based on the Golden Ratio for using nature as model which helps to further explain this notion.

Sustainability is also an important contributing factor and recurring theme throughout the process of biomimicry. Essentially, it is the goal when using biomimicry within the realm of design to create hybrids of timeless, sustainable pieces. This is where nature as measure is introduced. In learning from the principal factors that work within nature, we can then embed them into our own sustainable design solutions.

Lastly, in viewing nature as mentor, it is a summation of how one should view nature with a modern outlook. It is vital to note that biomimicry introduces an era based not on what we can extract from nature and all that it encompasses but on what we can potentially take away and learn from nature. When the world of biomimicry and graphic design mesh, a beautiful landscape of opportunities will emerge.

The challenge at hand is to take these time-tested ideals nature has produced over the years and echo them to produce effective design solutions. By constituting nature as model, measure and as mentor, a new way of evaluating and creating effective design solutions will emerge out of the abyss of the already creative design process to an entirely new, innovative process full of potential.

Biomimicry can be used as a tool to create more sustainable design solutions because it is a design methodology itself, occurring in the ideation phase of the graphic design process rather than the execution phase. For instance, a designer would start with a human design problem, identifying the root of challenge and then review how nature would go about solving this problem. *What would nature do?* It is crucial to look at the natural form, process, and system already found within nature so one can mimic its process within the ideation stage.

There will be a cross-fertilization of ideas along the way, but in the end, the juggernaut of biomimicry will shed a new light onto the field of graphic design. Thus creating an avant-garde mode of thinking which in turn will lead to an alternate, innovative and revolutionary graphic design process.

OBJECTIVE

Scope of Project

The idea for this thesis project came to me after many scrutinizing hours of brainstorming and asking myself: What is it that I want to say after the culmination of my six years of design study and education? I knew I wanted to create something that had the ability to change designers perceptions, ultimately challenging the current paradigms. I also knew I wanted to demonstrate how design cannot only be good, but *do* good. I am always amazed and inspired by how elegantly ecosystems thrive, foster cooperative relationships, and adapt to ever changing conditions and wonder, how can graphic design find its niche within the current thriving ecosystem today? So, I chose to integrate two very distinct disciplines, graphic design and biomimicry, not only because I am passionate about both areas, but I feel that in order to design for the greater good, it is necessary to look to nature in order to do so. This is essentially what biomimicry strives to do. It looks to organisms and their natural ecosystems to draw inspiration and emulate their designs in the best way possible. Nature's design principles have developed over 3.8 billion years and have produced the most ecological, timeless, and constructive design solutions so not only is it logical to look to nature to solve our problems, it is crucial for our survival if we wish to generate any positive changes for our future.

As with any creative process, it requires practice for it to become second nature. This new graphic design + biomimicry process I am proposing is meant to challenge the current paradigms and create the potential for change. In doing this, I am aware that not all designers will agree with this new process or the ideas presented in this book and may think that some of them are a little too metaphorical, per say.

Yet this is the beauty of biomimicry; it allows designers to echo actual strategies and principles found within nature, creating an entirely new design that one may never have thought of before.

Naturally, as designers we are problem solvers. We apply our creative talents to finding new and appropriately innovative solutions to common questions. These questions may include how to best articulate a brand, how to connect with a particular audience or how to communicate across cultural boundaries.[1] Now more than ever there are bigger problems than just brands and connecting to consumers. There are fundamental needs such as equality, education, food, water, community, and sustainability. As graphic designers we should be creating work that has a purpose. There is a lot of beautiful graphic design work being done everyday, but what is it for?

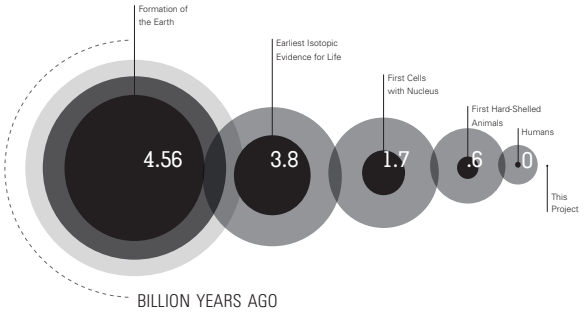
This book is also about trying to find work that has meaning and that will ultimately make a positive impact. I understand there is very necessary work designers must do every day that may not have the most meaning to them or influenced by nature's designs. I am not saying that biomimetic graphic design and *good* design should be held above that of design which seeks to do anything less than help save the world. Good design in this context is defined as being made using life's principles, eco-friendly materials, optimizes all materials rather maximizing, involves cross-disciplinary teamwork, etc. Any inference that the work presented within this thesis and final print application or *good* graphic design work that applies life's principles or uses eco-friendly materials is more noble or worthy is not my intention. The purpose of this thesis and this book is to raise awareness, propose a new mindset and celebrate this newfound biomimetic graphic design process. Whether for the greater good or greater profit, it is all still why we do what we do.

[1] Christopher C.H. Simmons, *Just Design*

That said, it is very easy for graphic designers to get caught up in only pleasing clients, focusing on articulating their message in order to communicate with their audience. Sometimes designers become too focused on one aspect and forget about how their piece will fit in with the rest of the 'ecosystem' and the other functions a piece should serve. Since we work in a cultural business, we have the potential to change our client's perceptions of their consumption patterns as well as our own, helping to reduce our overall carbon footprint. This perhaps is the greatest leverage point for biomimetic-graphic design. We must learn to be a part of a multi-disciplinary brainstorming team in order to identify the best leverage points for the most change.[2] After engaging in this book, designers will know how to do this, using the biomimetic principles to help guide them. I am hoping designers will try to incorporate this new design process and take away a new mode of thinking; applying this process not just into their work, but into all aspects of their lives allowing them to be more creative overall.

[2] Jessica Jones, Design Momentum Blog http://designmomentum.wordpress.com

In this book I have tried embracing what others have done before me, exhibiting what they have found and proposing my own ideas and solutions. This is the accumulation of all my research and should act as a catalog of my ideas and findings. Hopefully after looking and reading through this reference guidebook, designers will be encouraged by this different way of thinking, forcing themselves to innovate, experiment, push and adapt their designs further than ever before. The objective at hand is to create good design that also has the potential to *do* good, for the world and everything that encompasses it. We are on the cusp of great change: will designers curl up at the thought of this or embrace this new mode of thinking to help shape a positive future for design, people, and most importantly, our planet?



Life's design brief is simple.
Learn how to create and make things while creating conditions conducive to life on earth.

JANINE BENYUS

[1] Janine Benyus, Biomimicry in Action July 2009 TED Talks www.ted.com

1 **DEFINING**
ANALYZING
OBSERVING
SELECTING
IMPLEMENTING
EVALUATING

What Would Nature Do?
Nature is the ultimate designer, developing processes that over time continue to produce effective and timeless design solutions. Imagine designing Spring, or any season for that matter. How would you orchestrate it? How would you delegate? Imagine the timing, the precision, the coordination without the protocols. There is a lot of showing off, love in the air, grand openings...the organisms have all of their priorities in order.[1] Each one with its own process and system knows what to do, when to do it, and how to do it. Designing Spring? A piece of cake...for nature that is.

AWARENESS

Innovators at the Institute

One person in particular has been devoting her life and career to biomimicry, studying its methodologies and principles over a long period of time. Her name is Janine Benyus, the pioneer responsible for the breakthroughs in the field of biomimicry. Her work has been a catalyst for many innovations that emulate nature's processes and has been used in the research, design and manufacturing of many products. She is currently the president of the Biomimicry Institute as well as a biologist at the design table, innovation consultant, and author of six books including *Biomimicry: Innovation Inspired by Nature*. Benyus began her career in 1996 co-founding the Helena, Montana based Biomimicry Guild with Dr. Dayna Baumeister. Then, in 2005 she co-founded The Biomimicry Institute with Bryony Schwan and in 2007 Chris Allen joined the team to help launch the ground-breaking database *AskNature.org*, the world's first digital library of nature's solutions containing nature's answers to many complex design challenges.[1] Her in-house biologists at the Guild have provided consulting services in design, manufacturing and management to hundreds of corporations, universities, architectural firms and NPO's, including GE, HOK, Boeing, Herman Miller, Interface, Kohler, Kraft, Nike, IDEO and Procter & Gamble. She has also helped to introduce tens of thousands of people to the exciting field of biomimicry through international presentations such as TED talks and GreenBuild. In 2008, Benyus received "Time Magazine's" Heroes of the Environment award and in 2011, she was a recipient of a prestigious Heinz award in the sum of $100,000. Teresa Heinz, chairman of the Heinz Family Foundation, described her as "showing us that the solutions to many of our biggest challenges are right there in front of us in nature's vast reservoir of ideas."[2] While biomimicry has existed as a tool in fields such as chemistry for years, as a methodology it had not crossed over into other disciplines until Benyus took the first stride in doing so.

[1] Biomimicry 3.8
http://biomimicry.net/

[2] The 17th Heinz Awards
http://www.heinzawards.net

Janine Benyus is also the visionary co-founder of Biomimicry 3.8, formed by integrating The Biomimicry Institute and The Biomimicry Guild in 2010. Biomimicry 3.8 brings together scientists, engineers, architects, designers and other innovators to create sustainable technologies and business practices. The organization achieves this through a global network of experts providing education, professional training, research, analysis and consultation to individuals, institutions and corporations. It is vital to note that the Institute is a not-for-profit organization that promotes the study and imitation of nature's remarkably efficient designs to use those models to create sustainable technologies.[3] Today, Biomimicry 3.8 also offers short-term workshops and two-year certificate program in biomimicry for professionals.

Biomimicry 3.8 focuses on three areas:

1 Developing educational programs for students, professionals and the general public

2 Working to create public policies that use biomimicry as a solution to sustainability challenges

3 Encouraging companies that are profiting from biomimicry to provide financial support for biodiversity

Thanks to the efforts and work of the biologists, designers and innovators at Biomimicry 3.8, more and more designers are realizing a simple truth when trying to find responsible, ecological solutions: If we're trying to do it, chances are, nature already did it better.[4]

[3] The Biomimicry Institute
http://www.biomimicryinstitute.org/

[4] Alissa Walker,
What Would you Ask Nature?
http://www.fastcompany.com/

INDUSTRY STANDARDS

Modern Design Practices

Biomimicry is quickly becoming a cornerstone for sustainable design practices and the Institute and Guild have worked with companies to help them achieve ground-breaking designs, products, and materials all inspired by nature. Designers from all over the globe, designing everything from toothbrushes to trains and airplanes, are working to integrate the principles of biomimicry and sustainability into all aspects of design. This includes education, to practice and production, and ultimately consumption. What is happening here within the creative industry is that new standards are being set, ultimately challenging the current paradigms that exist in modern design. Designers are starting to catalyze this new system and way of thinking by collectively building their intelligence around important issues such as climate change and social justice, and tackling those issues and challenges with optimism and creativity. This is the satisfaction a designer is able to attain when modeling his/her work using the biomimetic + graphic design principles. They come up with ideas that they may have never thought of before that nature brilliantly thought of and designed millions of years ago. These ideas can suddenly turn into the most remarkable, yet simplest ideas. In taking these older ideals devised by nature and applying them within a new process, creates designs that are timeless, innovative, and revolutionary.

However, it is not as simple as it may seem at first. Many designers who want to incorporate biomimicry into their work and design process may not know where to start. Some famous biomimetic solutions have gotten passed around the mainstream press— including examples like self-cleaning surfaces modeled on lotus flowers, or the sticky repositionable tape inspired by gecko feet or wind turbines inspired by whale fins— but biomimicry is not as easy as using nature as a crib sheet.

[1] Alissa Walker, What Would you Ask Nature? http://www.fastcompany.com

[2] Alissa Walker, What Would you Ask Nature?

[3] The Biomimicry Guild http://www.biomimicryguild.com/guild_badt.html

[4] Alissa Walker, What Would you Ask Nature?

"One of the big realizations that designers have when they play with biomimicry is that it's not a tool, it's a mindset shift," says Dayna Baumeister, who co-founded the Biomimicry Guild with Benyus in 1996. "Because of that— because of the fundamentally different way of thinking— it's hard." [1] "Even for biologists, it requires a shift in thinking," says Baumeister, "from learning about nature to learning from nature, including how each of those processes fit within a larger ecosystem." "In a way, it's examining nature's solutions for survival, but through a design lens," says Chris Allen, project manager for *AskNature.org*. "You can look at brilliant engineering and strategies living for over thousands of years."[2]

Because biomimicry experts believe that designers play an integral role in making sustainable, nature-inspired decisions in a project, they believe that is where their influence is best appropriated. A biologist working in biomimetic design is known as a Biologist at the Design Table, or, in a biomimetic-appropriate acronym: a BaDT.[3] BaDTs create a bridge to biological understanding. Biomimetic work is deeply rooted in solid science, but it is a BaDT's job to translate that science so designers can immediately make the link to the design challenge. This way biologists are able to be part of the design team from brainstorm to prototype, continually adding biological insight to the process. There are currently very few BaDT's— only about 75 worldwide— since they have to undergo extensive training.[4] But eventually, the goal is to have a BaDT in every design firm who can help guide the designers towards smarter, more nature-influenced solutions.

It is crucial that designers embrace this new set of biomimetic standards and understand that the cross-disciplinary dialogue is a vital and necessary component within the design process in order to emulate designs found within nature. Designers need to continue to collaborate with other professionals. Not strictly biologists, however, but also scientists, engineers, architects...The more areas of expertise in the room, the greater the range of possibilities in coming up with timeless, sustainable design solutions. This new process also gives designers and professionals the competitive edge within the industry. People are extremely invested and interested in the field of biomimicry because it has produced some of the most successful and innovative designs seen today. When products are designed with the biomimetic industry standards, not only are they aesthetically pleasing, they are also modern, functional, sustainable, cost-effective and life-friendly designs.

As previously mentioned, the Guild has worked with world-class companies to help them achieve this shift in thinking, from a long-standing relationship with the flooring and finishes company Interface, to a team currently on-site at an architectural project in India. In India, they are creating buildings that not only are made from natural materials, they actually behave like natural organisms.[5] Using biomimetic principles, we have also been able to learn more about our own species. The Guild is starting conversations with global companies that manufacture goods such as cosmetics— in which case their own in-house scientists have been studying hair and skin for decades. Currently there is a great deal of excitement bridging algorithms found in nature and information technology or 'generative design,' where we are able to extrapolate data from the way that nature goes through its iterative design process in evolution.

[5] Alissa Walker, *What Would you Ask Nature?*

It is important to note that to adopt this biomimetic mindset shift, one is also agreeing to adopt responsible design practices. Practicing responsible design is more than just using life-friendly materials and sustainable technologies. It is about raising awareness, getting involved and staying active. It is crucial to let others know about the exciting field of biomimicry and the current biomimetic standards. The easiest way to do this is to adopt these new standards within one's own process and to one's designs. It is also about being active within one's local community and getting involved with any programs or organizations that are striving to create a positive environmental impact. This is the only way to challenge the current paradigms and spread the word about biomimetic design.

Another way one can practice responsible design is to always be conscious of one's surroundings within one's local community and the larger ecosystem we reside in. Use materials that are found locally rather than 'outsourcing' to the internet. Always ask: *What Would Nature Do?* How would nature solve this design problem? If one looks hard enough, what will be found is that nature is where all of the answers to our design problems lie. Good, responsible design practice involves multiple viewpoints and is adaptive to new information.[6]

[6] Wendy Jedlicka, *Sustainable Graphic Design*

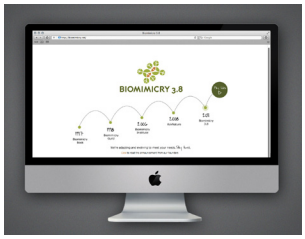
RESOURCES

You have read, defined and now know the basis of what it means to integrate biomimicry + design, and hopefully you are inspired and want to learn more! The following resources will provide a good starting point.

BIOMIMICRY 3.8

http://biomimicry.net/

The Biomimicry 3.8 website provides the basics about biomimicry + design and gives you information on various learning opportunities and workshops, as well as biomimicry-related activities going on at academic institutions around the world. Exploring the Case Studies will give you a feel for how biomimicry plays out by emulating nature's forms, processes, and systems. Make sure you sign up for the Biomimicry Newsletter so you can stay up-to-date with all of the exciting biomimicry inspired designs happening today!



TED

http://www.ted.com/

TED is a nonprofit organization devoted to Ideas Worth Spreading. It began in 1984, starting out as a conference bringing together people from three worlds: Design, Entertainment, and Technology. Since then its scope has become ever broader.

Janine Benyus has been appearing on TED since 2005 as a speaker in their TED Talks. She shares her brilliant insight and developments on biomimicry, providing heartening examples of ways in which nature can influencing our current designs and technologies.

There are other inspirational videos to see as well on various biomimicry topics and design.

CHECK OUT

Benyus: Biomimicry in Action

Benyus Shares Nature's Designs

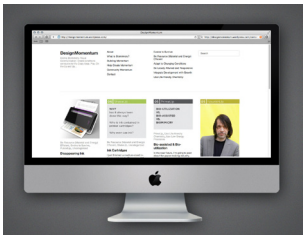
DESIGNMOMENTUM

http://designmomentum.wordpress.com/

This blog was created by one of the designers and visual communicators at Biomimicry 3.8, Jessica Jones. Its purpose is to promote the biomimetic way of thinking. She has carefully organized her thoughts and research over the years into several sections revolving around the word 'momentum.'

DesignMomentum is meant to help build and create momentum within the small niche of graphic design and biomimicry. This is all in hopes of raising awareness of life's principles and to foster and bring forth a new, alternative design process, promoting positive change within the design community.

It provides excellent case studies to best illustrate her points, helping others to understand how designing from nature and using life's principles can create some of the best design solutions.



BOOK LIST

What you should read next...

Biomimicry: Innovation Inspired by Nature
Janine Benyus

Biologic: Designing with Nature to Protect the Environment
David Wann

Cats' Paws and Catapults: Mechanical World of Nature and People
Steven Vogel

Cradle to Cradle: Remaking the Way We Make Things
William McDonough & Michael Braungart

Deep Design: Pathways to a Livable Future
David Wann

Design Lessons from Nature
Benjamin De Brie Taylor

Nature's Operating Instructions: The True Biotechnologies
Kenny Ausubel

On Growth and Form
D'Arcy Wentworth Thompson

Sustainable Graphic Design
Wendy Jedlicka

Structural Biomaterials
Julian Vincent

The Way Nature Works
Robin Rees

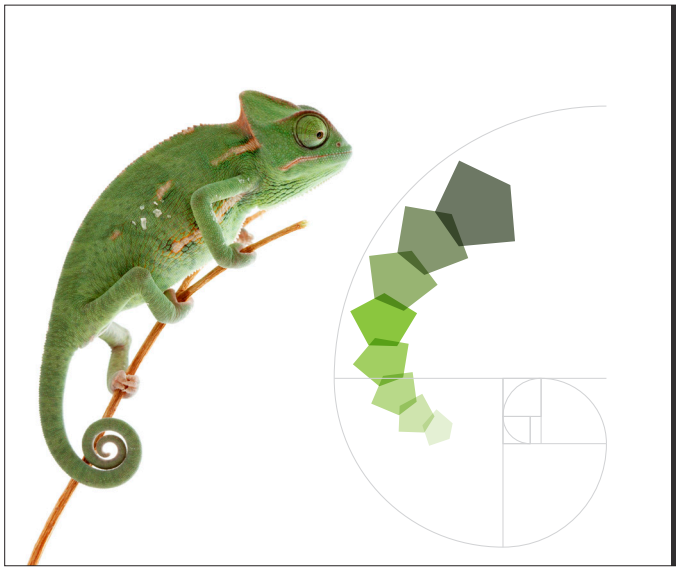
Biomimicry focuses on finding structures, processes, strategies and mechanisms that nature has been using for a billion years, that we can emulate and use in modern design.

TERRY TEMPEST WILLIAMS

DEFINING
2 **ANALYZING**
OBSERVING
SELECTING
IMPLEMENTING
EVALUATING

How Would Nature Begin?

In asking this question, it is integral to first consider how nature communicates. How would nature begin its design process, delegating specific tasks to each organism to confirm the design gets completed? Not just completed, but completed in the *right* way and in the most *sustainable* way conducive to life. These are fairly simple questions with many elegant insights and all the answers lie within nature and the organisms that keep our ecosystem revolving. This second step in the process after defining the problem or issue is *analyzing*. Nature has been innovating for 3.8 billions years and has already solved many of the design challenges we are having today. So in order to understand nature's process, we must perform a comprehensive analysis.



METHODOLOGY

Biomimicry + Graphic Design

To better fit in with the rest of nature, humans (graphic designers) can more correctly identify the problem, filter through nature's solutions, think in a systematic perspective, and design for human user experience.[1] Exploring how to integrate biomimicry + graphic design is one of the many avenues to a more sustainable world and is arguably one of the most powerful leverage points to creating conditions conducive to life. Before exploring how biomimicry can help graphic designers create more sustainable solutions, it is essential to revisit the methodology of each discipline so one can understand how both can work together.

METHODOLOGY OF BIOMIMICRY

Biomimicry is the conscious emulation of nature's genius— innovation inspired by nature.[2] In a society accustomed to dominating or 'improving' nature, this respectful imitation is a radically new approach; a revolution really. Unlike the Industrial Revolution, the Biomimicry Revolution introduces an era based not on what we can extract from nature, but on what we can learn from her.[3] Biomimicry's methodology is analyzing nature and mimicking it's functions and deep patterns to create life-friendly solutions. It is not the aesthetic mimicry of something without function, a point especially important for aspiring biomimetic graphic designers.[4] For example, biomimicry is not converting your canvas size to be the same proportion as the golden ratio because this ratio in nature serves as a streamlining function for growth and water flow. Biomimicry is not die-cutting your piece into the shape of a nautilus shell or simply using color palettes found in nature. This is a common misconception among designers who are just learning and being introduced to biomimetic graphic design.

[1] Jessica Jones, DesignMomentum Blog http://designmomentum.wordpress.com/

[2] Janine Benyus, *Biomimicry: Innovation Inspired by Nature*

[3] Janine Benyus, *Biomimicry: Innovation Inspired by Nature*

[4] Jessica Jones, DesignMomentum Blog

[5] Kenny Ausubel, *Nature's Operating Instructions*

The golden ratio or color palettes found within in nature are a good place to start and use for inspiration, but then one must take these and adapt them in a way that nature would within its ecosystem, providing not only form but function as well. This is where the methodologies of graphic design and biomimicry intertwine, using some of the basic elements and principles found within design and nature.

Mimicking form, function or shape is just the first step of becoming better adapted. Learning from nature really means remembering nature's processes and ecosystem strategies, that everything is created and done in context for a particular reason in conditions that are conducive to life.[5] Until we understand this and create designs and products that mimic living systems and processes rather than a machine, we have not reached the full potential of biomimicry.

Since biomimicry has emerged as an ever-evolving discipline, it has proven that life and nature has a lot to teach within the realm of technology and design. The methodology and biomimetic approach is taking the design principles and genius of the natural world and looking at their solutions in order to solve current design challenges. It is simply going out into nature to see her solution to the problem. When it comes to people's understanding of biomimicry, there is not a lack of information, but a lack of integration. What is necessary today in order for designers to create and practice with greater holistic awareness and sustainability is an integration and meshing of both methodologies. Nature has had over 3.8 billion years to research and develop well-adapted solutions including 10 – 30 million different species. Organisms have already solved the problems that designers, engineers, and architects have spent years working on. The answers are everywhere and in order for designers, engineers and architects to see these answers, what is needed is a change in the lens with which they are seeing and observing.

The significant aspect to note is that these solutions are solved in context; that context is the earth…the same context with which we are trying to solve design problems. The question designers should ask themselves is how does life make things without using harsh chemicals and manufacturing products via factory lines? How does life make 'things' disappear into systems? The answer is simple. Life creates conditions conducive to life. It builds soil, it cleans air and water, mixes the cocktail of gases that every organism needs to live all while doing it in the middle of great foreplay, and meeting every species' needs. Organisms have figured out a way to do the amazing things they do while taking care of the place that is going to take care of their offspring.

A prime example of an organism that has been doing this is the hummingbird, an organism about the size of a human thumb. It flies up to 35 miles an hour (faster than people can get around most cities in a cab) and migrates about 2,000 miles a year. Those journeying down the eastern flyway reach the tip of the Gulf of Mexico and then pause for a period of time, fueling up on 1,000 blossoms a day. Finally, they burst across 600 miles of open water without stopping, on a whopping 2.1 grams of fuel. And that is not jet fuel: it is nectar. But here is what is amazing. In the process of fueling up, the hummingbird manages to pollinate its energy source, ensuring that there will be nectar next year— for itself, for its offspring, or for completely unrelated species of nectar feeders. Imagine doing that at a gas station. And of course, when it dies, its body decays and nurtures the roots not only of flowers, but of mushrooms, grasses, trees, and shrubs. There is nothing special about it; no government regulations are behind it. It is simply part of the system that keeps us alive.

Much of the research in biomimicry is years and years from fruition, yet it is a path; an approach. It requires designers to visit the outdoors and keep asking: How does nature teach? How does nature learn? How does nature heal? How does nature communicate? As humans, we may learn faster but nature has been at it longer. So quieting human cleverness and getting over this fact is the first step in biomimicry. Next, comes listening, then trying to echo what we hear. This emulating is hard and humbling work. When what we learn improves how we live, we grow grateful and that leads to the last step in the path: stewardship and care-taking, a practical thanksgiving for what we have learned.[4]

[4] Kenny Ausubel, *Nature's Operating Instructions*

METHODOLOGY OF GRAPHIC DESIGN

Designers are visual communicators. In order to create, we have to go through a process. It requires being innovative, meticulous and resourceful, taking each project from initial concepts to a final design solution. In the simplest of terms, we take a design problem, generate ideas through sketching and brainstorming and implement the best idea to produce a successful design solution.

However, design is not entirely about juxtaposing images and text to produce content in relation to the context of the problem. It has the power to do more. There is a common misconception among the general public (non-designers) who may not be aware of the methodology of graphic design or what graphic designers do. Some may think that all graphic designers do is make and print *stuff* that will only end up in landfills as waste. This is such a negative outlook to have because then every designer would ask themselves, "Why am I designing this if it is just going to end up in the trash?"

Today we have the power to change that negative outlook and turn it into something positive. Take that piece of 'trash' and see how it can better fit within the larger ecosystem, creating conditions conducive to life and benefiting society rather than hindering it from reducing our carbon footprint. In order to explore graphic design as a strategic process to assist societal problems, one needs to think very differently in terms of multidisciplinary design teams and working directly within his/her local communities and cultural organizations. While this new process affects the graphic design methodology by instituting the use of natural processes, principles and influences to promote change within critical social issues; the role of good communication design is just as relevant. Herein lies an incredible opportunity for graphic designers to illustrate his/her social relevance, influence, and creativity by using biomimicry within one's process.

After assessing both methodologies, it is critical we look at both side-by-side to see the commonalities, as well as the drastic differences. There are really two schools of design and thought to analyze and evaluate; the graphic design (technologic, human) side versus the biomimicry (biologic, nature) side. Looking at both natural and human technologies forces us to think about each in novel ways. For the graphic designer, a perceptive look at nature's technology can do just that: It can provide the wide-angle view that reveals possibilities that would otherwise escape consideration. Also, this view of nature as technology has provided an unusual perspective on the natural world around us.[1] Recognizing that nature deals with the same variables as do human designers leads us to comparing both products and processes. The two sides and their technologies share the same planet, they experience the same pressures, temperatures, gravitational accelerations, winds, and water currents so why not examine them in this manner. It comes down to...what can we learn in doing this?

[1] Steven Vogel, *Cats' Paws and Catapults: Mechanical World of Nature and People*

GRAPHIC DESIGN (Technologic, Humans)	VS	**BIOMIMICRY** (Biologic, Nature)
Designers create something that does not exist		Biologists study something that exists: nature, in all its splendor
Human technology springs from what is variously called invention, discovery, development or planning		Nature's process is that mechanism Darwin uncovered, evolution by natural selection
Graphic Designers can borrow devices from other designers and history		Nature must follow an inherited plan set by genetic code and evolution
Humans have a great affinity for flatness		Nature makes very few flat surfaces
Designers love the mechanical and geometrical shapes, using right corners in abundance		Nature, on the other hand, uses very few right angles, if any, using curves and gradual gradients
Designers, and people, like to create by taking something and manipulating it into something else, taking away and adding, then disposing what was not used		Nature, however, would cut something into pieces and reassemble them from the ground up, building by lacing them together; optimizing the material with little to no waste to dispose of
Overly productive, using brute force resulting in excess, waste and pollution		Highly protective, using finesse resulting in conserving and nurturing
What can our technologies provide?		What do we *need*? How can nature provide?

Inspired by— thoughts of Steven Vogel, *Cats' Paws and Catapults* & David Wann, *Biologic*.

MEME

Nature's Design Principles,
Indirect Method

[1] New Oxford American Dictionary 3rd ed © 2010

Meme, by definition, means an element of a culture or system of behavior that may be considered to be passed from one individual to another by non-genetic means, esp. imitation.[1] Biomimetic graphic design in itself is somewhat of a 'meme.' It is a design process and style that has been spread and passed along throughout today's culture and society via various channels and networks of communication. To be active within this biomimetic graphic design unit, designers must transmit their ideas through the form of cultural analogues that can respond and adapt to the ever-changing times and conditions. To better understand this, it is critical that designers learn, memorize and apply the following design lessons and life principles nature has so graciously given us.

This is the indirect method of beginning to apply the two methodologies; biomimicry + graphic design, by using abstracted principles of how nature designs. These principles of nature are present in all organisms at multiple scales and levels that fuel and inspire deep sustainability. They are the criteria for thriving and surviving on earth, while creating conditions conducive to life and can be applied to all stages of the graphic design or visual communication process. Each principle challenges humans to think systemically within a broader context than just thinking of a single organism. The following principles are a distilled combination of those life's principles enumerated by the Biomimicry Institute and Janine Benyus, Michael Braungart and William McDonough (*Cradle to Cradle*), Steven Vogel (*Cats' Paws and Catapults*), D' Arcy Thompson (*On Growth and Form*), Julian Vincent (*Structural Biomaterials*), Jeremy Faludi (sustainable design strategist and researcher, articles for *Worldchanging.com*) and my own limited experience of knowledge and research on the subject of biomimetic design.

14 Design Principles of Nature

1. Self-Assembly from the Ground Up
2. Waste = Food
3. Evolve Solutions, Don't Plan Them
4. Adapt to Changing Conditions, Adjust to the Here & Now
5. Respect Diversity, Diversify to Fill Every Niche
6. Self Appropriate Technologies
7. Be Resourceful
8. Optimize Rather than Maximize
9. Use Life-Friendly Chemistry
10. Organize Fractally
11. The Entire System is Greater than the Sum of Its Parts
12. Leveraging Interdependence, Feedback Loops
13. Foster Cooperative Relationships
14. Don't Foul your Nest

1 Self-Assembly from the Ground Up

The most important things happen at the smallest scales. For instance, on the material level, instead of taking a block of something that you cut away, take small parts that combine to form the whole. This reduces waste and increases design flexibility.

Jessica Jones, the graphic designer and visual communicator at the Institute put it very eloquently when I spoke with her via phone conference...

> If you gave nature a piece of construction paper and asked it to make a leaf, it would cut it into pieces and then reassemble the pieces from the bottom up...but humans would take it, take scissors and cut the shape out of it. (story original told by Janine Benyus)

On the system level, design networks, not pyramids. The nodes should create the overall structure by their interrelations, because this method is more robust, scalable, and flexible than a system with an over-arching plan that must have certain nodes in certain places.[1]

The second aspect of this, 'the most important things happen at the smallest scales,' refers to the fact that the most complex, detail-filled aspects of biological designs are done at the smallest scales: at first, a bone looks like a stick; look closer, and you see its porous structure; look closer, and you see the material is a composite; look closer, and you find that composite has three or four deeper levels of substructure; look closely enough and you get to the DNA, which is complex enough to contain the blueprints for the whole bone and the rest of the animal.[2] Sometimes designing for the most minute detail can cause the whole over-arching design to be determined.

[1] Jeremy Faludi, Biomimicry for Green Design Worldchanging: Change Your Thinking

[2] Jeremy Faludi, Biomimicry for Green Design Worldchanging: Change Your Thinking

2 Waste = Food

This perhaps is one of the most important principles, using waste as a resource rather than disposing of it off in a landfill. Michael Braungart and William McDonough, authors of *Cradle to Cradle: Remaking the Way We Make Things,* have the best developed model for this, with their concept of biological nutrients and technical nutrients. Strictly speaking, as Janine Benyus points out, modern industry does act like ecosystems in nature— a 'type 1' system, the weeds that colonize an area after a disturbance. However, type 1 ecosystems are not sustainable, they eventually give way to type 2 and type 3 ecosystems, which have increasingly greater interdependencies, with increasingly closed-loop resource flows, such as rainforests.[3] Creating type 3 industrial ecosystems has historically been tricky to implement because the pace at which products change, and markets change, are often rapid— industry has so far always been in a 'disturbed' state as new technologies change the rules of the game; natural ecosystems, by contrast, transform from type 1 to type 3 over thousands of generations of the species involved.[4] How can we help push industry forward? The adoption of open standards can help here, so that components are more interchangeable between products and industries— this helps manufacturing systems develop long-term stability standards needed for building webs of interdependencies. Likewise less dependence on new cutting-edge technologies makes it easier to fit into existing webs. An important corollary of 'Waste = Food' that Janine Benyus makes is "don't draw down resources, live off the interest."[5] It is a financial analogy, describing how mature (type 3) ecosystems do not need new income since they are living off of the interest from the great biological wealth they have acquired over time. Mining or harvesting too much of the world's existing natural resources is like spending the capital you are trying to live off the interest of, and it will catch up to you.

[3] Janine Benyus, *Biomimicry: Innovation Inspired by Nature*

[4] Jeremy Faludi, Biomimicry for Green Design Worldchanging: Change Your Thinking

[5] Janine Benyus, *Biomimicry: Innovation Inspired by Nature*

3 Evolve Solutions, Don't Plan Them

This means to design without authorship and to let go with dignity. Many designers may not be fond of this third principle because it strives away from the traditional process of artists and *their* work. It is now about creating the right context for possibilities to emerge. As Jeremy Fauldi explains, the most direct example is genetic algorithms. Their huge success has proven the usefulness of this technique and principle. This in turn falls back onto the idea of design being iterative and continuous. That is making multiple prototypes, user-testing them to find the favorites and most successful, then mixing and matching elements from each to create another generation of prototypes which are in turn user-tested, ad infinitum.[6] Incidentally, this is the method advocated by IDEO, one of the most successful design firms in the world.

[6] Jeremy Faludi, Biomimicry for Green Design Worldchanging: Change Your Thinking

4 Adapt to Changing Conditions, Adjust to the Here & Now

This fourth principle directly applies to Darwinian evolution; true evolution in the sense that a design is never done, it is only a means of adaptation. As Janine Benyus says, effective adaptation requires organisms to be information-driven, with local expertise.[7] It also requires timely expertise. Species that range across dramatically different habitats must adjust themselves to the new locales, and those that stay in the same place but whose habitat changes (say, from summer to winter) adjust as well; i.e. hibernation. In the product world this means customizing for different users and different circumstances, to extend the product life-cycle. In more advanced implementations, it means the products adjust themselves without need for user intervention.

[7] Janine Benyus, *Biomimicry: Innovation Inspired by Nature*

5 Respect Diversity, Diversify to Fill Every Niche

Respect diversity as a tenet can be very broad, covering a global level but it can also be scaled down to be compared to the industry, market and product level. In regard to the global level, it is showing a wide scope of respect and honor to all cultural, ethnic, racial, sexual, religious and spiritual diversity of beings within the context of individual responsibility.[8] To respect and maintain biodiversity or a diversity of living species for a chance to change and evolve through natural selection is key.

On the market level, traditional industry already adapts to this. However, on the product level, mass-customization does a similar thing. The biomimetic-design lesson here ties in with the second principle, 'Waste = Food.' It is to find untapped niches where waste is being created, where it could instead be used as a resource. Smart manufacturers close their own resource loops; smart entrepreneurs close other peoples' loops.[9] Solving a problem using a single solution, with no diversity, may make it vulnerable to outside influences.

[8] David Wann, *Deep Design: Pathways to a Liveable Future*

[9] Jeremy Faludi, Biomimicry for Green Design Worldchanging: Change Your Thinking

6 Self Appropriate Technologies

This sixth principle is fairly simple: use the right tools for the right job. This ensures time and cost efficiency and it also prevents the act of re-design. This also ties in with the first and second principles, 'Self-Assembly from the Ground Up' and 'Waste = Food.' In self appropriating technologies, it confirms less waste which means less cleanup; less conflict; fewer costs.

7 Be Resourceful

Being resourceful may seem like another fairly broad principle to apply, but generally speaking it encompasses gathering and minimizing efficient energy and materials needed to produce a successful design solution. In regard to *gathering* efficient energy and materials, you do not necessarily need to study nature to get the importance of this, but it has a cornucopia of strategies you may have never tried. For example, ants have been studied to improve shipping schedule algorithms, plant leaves have been studied for solar energy absorption, mollusks have been studied for building shells out of seawater without even moving.[10] The list goes on....

As for *minimizing* energy and materials to be resourceful, nature has an abundance of great examples. Plants and animals always try to use material and energy efficiently, because for them energy and material costs are the only costs. Successfully minimizing mass and energy use requires thorough optimization to the problem at hand, so organism structures are highly information-driven. On the other hand, industry's costs are primarily financial, so it usually finds it easier to simply use more material or energy than spend the extra time researching how to use it well. Yet, minimalist designs can be the most successful and cost-effective in the industry.[11]

[10] Jeremy Faludi, Biomimicry for Green Design Worldchanging: Change Your Thinking

[11] Jeremy Faludi, Biomimicry for Green Design Worldchanging: Change Your Thinking

8 Optimize Rather than Maximize

Optimize rather than maximize as a concept of creating designs that are multifunctional, always fitting form to function. This is general systems-thinking advice, but Benyus points out its ubiquitousness in biology. Creatures always have to balance multiple cost/benefit dimensions, there are no single-minded goals like being bigger or faster. A quick rule of thumb here is perform as many functions with as few components as possible, tying in the seventh principle of 'Be Resourceful' when it comes to selecting and gathering your materials. It is a good exercise to explicitly lay out all the factors you are trying to balance and organize. For instance, graphic designers can maximize the number of pages in a piece or the size of the paper which will probably allow for a more easily achieved eye-catching composition and attract more viewers; yet the functional design of the piece may be compromised if it is now too large for users.[12] Always remember to optimize all variables.

[12] Jessica Jones, Biomimicry: *Sustainable Graphic Design* by Wendy Jedlicka

9 Use Life-Friendly Chemistry

This principle, from both Benyus and Vogel, is fairly self-explanatory. Benyus describes the way we manufacture products is by 'heat, beat, treat.' She claims it has become the de-facto slogan of our industrial age; it is the way we synthesize just about everything. Nature, on the other hand, cannot afford to follow this strategy. Life cannot put its factory on the edge of town; it has to live where it works. As a result, nature's first trick of the trade is that nature manufactures its materials under life-friendly conditions— in water, at room temperature, without harsh chemicals or high pressures.[13]

[13] Janine Benyus, *Biomimicry: Innovation Inspired by Nature*

10 Organize Fractally

This tenth principle, organize fractally, looks at self-similarity in the way of planning for several different scales at once. Fibonacci spirals do not occur all over the place in nature because they are pretty, they occur all over because they are an algorithm that allows perpetual growth to any size without having to readjust or plan ahead. Fractal structures do not have to be as 'smart' as other structures which require different planning for different scales. This ties in with design having form and multi-functionality.

11 The Entire System is Greater than the Sum of Its Parts

People tend to design one function at a time, creating separate elements for each task and then creating the product by assembling all the pieces. There are many advantages to this, but in these products the whole will only be the sum of its parts. One of the hallmarks of complex systems is 'emergent phenomena,' the fact that the whole is greater than the sum of its parts.[14] An example of 'emergent phenomena' is looking at how an individual bee has a small brain and simple behavior, but a swarm of bees is a sophisticated organism all its own. Emergent phenomena are hard, if not impossible to predict, and in the built world mostly happen by accident. However, designing with it in mind can not only help avoid unintended consequences, but can open new opportunities— the democratizing force of the internet being a prime example.[15] The key to this principle is designing lots of little, simple things that together can do sophisticated things; this can be a biomimetic design tool because it lets you build robust systems without infrastructure, build smaller and smarter stuff without super-high technology.

[14] Jeremy Faludi, Biomimicry for Green Design Worldchanging: Change Your Thinking

[15] Jeremy Faludi, Biomimicry for Green Design Worldchanging: Change Your Thinking

12 Leveraging Interdependence, Feedback Loops

Inter-relatedness and leveraging interdependence systems relies on learning the lessons from the ecosystems that we are a part of. This principle basically outlines what the biomimetic + graphic design process tries to do. We need to learn how to work with the cycles of the sun, water, wind, and geothermal energy rather than depleting finite resources that can be more effectively used elsewhere.[16] In doing this, we can help to create a continuous locally attuned feedback loop that allows for the renewing of resources, recycling of all materials, and self-organizing of systems; all of which allows the fostering of cooperative relationships— the thirteenth design principle of nature. Natural ecosystems are able to sense boundaries and changing conditions, whereas humans are not so well adapted in doing. It is crucial that we look to these systems and feedback loops in order to solve our design problems in the most economical fashion.

[16] David Wann, *Deep Design: Pathways to a Liveable Future*

13 Foster Cooperative Relationships

Just as in a natural ecosystem where one organism lives off another, providing the nourishment it needs to survive; graphic designers use print manufacturers to ensure their jobs and designs survive. It is using the same cycle of give and you shall receive. Both need each other in order to survive within the creative design industry. So, fostering cooperative relationships means we need to encourage creative thinking and cultivate relationships with other designers and manufacturers in the industry in order to keep this continuous cycle going. For instance, a stock photography company allows a printing shop to give its clients (graphic designers) access to its database account. A client can use any photograph as long as it uses the printing shop for printing. In turn, the stock photography company receives more revenue/exposure, the printer receives more services, and the client receives complementary or reduced-cost photos.[17] It is actively seeking out a relationship to ensure positive business practices to get things done, benefiting all in the process.

[17] Jessica Jones, Biomimicry, *Sustainable Graphic Design* by Wendy Jedlicka

14 Don't Foul your Nest

This last principle is another genius idea of Benyus. 'Don't foul your nest' is saying that in the grand scheme of things, do not use or design with harmful materials or effluents. Do you really want to live in a home that gives off harmful gases such as formaldehyde or dioxins? This sounds simple and obvious, but if engineers, architects, and other builders actually started following this principle alone, it would cause a revolution.[18] This also refers to design in the sense that you should not 'foul your design' with any unnecessary components.

[18] Jeremy Faludi, Biomimicry for Green Design Worldchanging: Change Your Thinking

14 Design Principles of Nature


1 Self-Assembly from the Ground Up


5 Respect Diversity


9 Use Life-Friendly Chemistry


13 Foster Cooperative Relationships


2 Waste = Food


6 Self-Appropriate Technologies


10 Organize Fractally


14 Don't Foul your Nest


3 Evolve Solutions, Don't Plan Them


7 Be Resourceful


11 The System > the Sum of Its Parts


4 Adapt to Changing Conditions


8 Optimize Rather than Maximize


12 Leveraging Interdependence

GRAPHIC DESIGN

Universal Principles & Elements

When looking at graphic design and contemporary trends, it is apparent complexity is increasing because of the expansion of new technologies. With technological and societal advances, emphasis is now placed on new applications including tablets, mobile devices, e-books, etc. The major focus is no longer on pure form generation which has been the case in the past, but instead, is placed on other elements such as device, user needs and involvement, affordability, resources, and environmental concerns. Although, this is not to say that form generation is not an important aspect to the field anymore because it is still one of the most important facet of graphic design; there are just other elements that designers today need to be aware of that designers in the past did not. For instance, web designers now need to be aware of responsive design, ensuring that their design not only looks good on a desktop, but on smaller scales such as tablets and smartphones.

Although these digital technologies afford greater freedom and flexibility, they can often cut short the creative window for concept development and creative thinking. People, places, thoughts and things become familiar through repeated exposure.[1] There is much temptation to turn directly to the computer and type in a Google search. This often results in images or ideas that are tired and trite. It is important that designers do not get trapped in the technological pitfall of leaving little to no imagination or bypassing the creative brainstorming processes of sketching and ideation.

Although every designer has his/her own creative process, all are based on the foundation of knowing the basic elements and principles of design including balance, rhythm, proportion, dominance, unity, form, shape...However, there are other principles that designers should remind themselves of such as

[1] Ellen Lupton & Jennifer Cole Phillips, *Graphic Design:The New Basics*

Hick's Law, Ockham's Razor, etc. Graphic design is a discipline directed toward the development and distribution of information in a visually creative way. Instead of the all of the focus being directed towards distributing the information in the best manner to please clients; the larger focus should now be how can one experiment with this visual language, while integrating nature in a way that still conveys a message. This is in hopes of ultimately producing a form of universal design. Good design has often been labeled as being based on a type of logic, grid system and structure with a resolved plan. For instance, a well designed logo is usually a progression of ideas and forms, sketching and re-sketching until the final design is achieved. What needs to be stressed is that there is a level of importance in sketching and process that unfortunately in modern design practices with the acceleration of technology, is getting lost due to immediate satisfaction with internet access. It is important to reassess and look back to the basic principles found within nature in order to move forward. In doing this, it will ensure that the work designers produce in the future will continue to be successful, timeless, and sustainable.

14 Universal Design Principles & Elements

The following 14 Universal Design Principles and Elements are an extension of Nature's 14 Design Principles to show how both relate and correspond to each other within the biomimetic design process.[1]

Each design principle falls into 1 of the 3 categories:
Form
Systems
Thinking

[1] For more detailed synopsis of the principles, reference *Universal Principles of Design* by William Lidwell, Kritina Holden and Jill Butler (descriptions seen here are excerpts from this book)

Category	
	Form
1	Form Follows Function
2	Mimicry
3	Self-Similarity
4	Symmetry
5	Uniform Connectedness
	Systems
6	Convergence
7	Feedback Loop
8	Hick's Law
9	Hierarchy of Needs
10	Life Cycle
	Thinking
11	Depth of Processing
12	Five Hat Racks
13	Mental Model
14	Ockham's Razor

Form The following design principles pertain to the form and physical shape of a(n) object(s)

PRINCIPLE	DESCRIPTION	RELATION
1 Form Follows Function	Beauty in design results from purity of function. The form follows function axiom is interpreted in one of two ways— as a description of beauty or a prescription for beauty. The descriptive interpretation is that beauty results from purity of function and the absence of ornamentation. The prescriptive interpretation is that aesthetic considerations in design should be secondary to functional considerations. When making design decisions, focus on the relative importance of all aspects of the design—form and function— in light of the success criteria.	 7 Be Resourceful
2 Mimicry	The act of copying properties of familiar objects, organisms, or environments in order to realize specific benefits afforded by those properties. In nature, mimicry refers to the copying of certain properties to hide from or deter other organisms. For instance, the viceroy butterfly mimics the less tasty monarch butterfly to detect predators. In design, mimicry refers to copying properties of familiar objects, organisms or environments in order to improve the usability, likability, or functionality of an object. There are three basic kinds of mimicry in design: surface, behavioral, and functional. Mimicry is perhaps the oldest and most efficient method for achieving major advances in design. Consider surface mimicry to improve usability, ensuring that the perception of the design corresponds to how it functions or is to be used.	 4 Adapt to Changing Conditions

PRINCIPLE	DESCRIPTION	RELATION
3 **Self-Similarity**	A property in which a form is made up of parts similar to the whole or to one another. Many forms in nature exhibit self-similarity and as a result it is commonly held to be an intrinsically aesthetic property. Natural forms tend to exhibit this at many different levels of scale, whereas human-created forms generally do not. This naturally occurring self-similarity is usually the result of a basic algorithm process called *recursion*. Recursion occurs when a system receives input, modifies it slightly, and then feeds the output back into the systems as input. The ubiquity of self-similarity in nature hints at an underlying order and algorithm, and suggests ways to enhance the aesthetic composition of human-created forms and perhaps their structural composition as well. Consider self-similarity in all aspects of design: story boarding, visual displays and structural compositions. The reuse of a single, basic form to create many levels of metaforms mimics nature's tendency towards parsimony and redundancy and can create interesting organizations at multiple levels of scale.	 10 Organize Fractally
4 **Symmetry**	A property of visual equivalence among elements in a form. Symmetry has long been associated with beauty, and is a property found in virtually all forms in nature. It can be seen in the human body as well as plants and animals. Symmetry in natural forms is largely a function of the influence of gravity and the kind of averaging of form that occurs from merging genetic information in reproduction. There are three basic aspects of symmetry: reflection, rotation, and translation. Use symmetry in design to convey balance, harmony, and stability.	 9 Use Life-Friendly Chemistry

PRINCIPLE	DESCRIPTION	RELATION
5 **Uniform Connectedness**	Elements that are connected by uniform visual properties, such as color, are perceived to be more related than elements that are not connected. This is one of the *Gestalt principles of perception*, asserting that elements connected to one another by uniform visual properties are perceived as a single group or chunk and are interpreted as being more related than elements that are not connected. There are two basic strategies for applying uniform connectedness in design: common regions and connecting lines. Common regions are formed when edges come together and bound a visual area, grouping the elements within the region. Connecting lines are formed when an explicit line joins elements, grouping the connected elements. Use uniform connectedness to visually connect or group elements in a design. Employ common regions to group text elements and clusters of control elements, and connecting lines to group individual elements and imply sequence.	 11 The System > the Sum of Its Parts

Systems The following design principles pertain to entire systems of design and how they function over time

PRINCIPLE	DESCRIPTION	RELATION
6 **Convergence**	A process in which similar characteristics evolve independently in multiple systems. Natural or human-made systems that best approximate optimal strategies afforded by the environment tend to be successful, while systems exhibiting lesser approximations tend to become extinct. This process results in the convergence of form and function over time. The degree of convergence in an environment indicates its stability and receptivity to different kinds of innovation. Consider the level of stability and convergence in an environment prior to design. Stable environments with convergent system designs are receptive to minor innovations and refinements but resist radical departures from established designs. Unstable environments with no convergent system designs are receptive to major innovations and experimentation, but offer little guidance as to which designs may or may not be successful.	 13 Foster Cooperative Relationships
7 **Feedback Loop**	A relationship between variables in a system where the consequences of an event feed back into the system as input, modifying the event in the future. Every action creates an equal and opposite reaction. When reactions loop back to affect themselves, a feedback loop is created. All real-world systems are composed of many such interacting feedback loops— animals, machines, businesses, and ecosystems. There are two types of feedback loops: positive and negative. Positive feedback amplifies system output, resulting in growth or decline. Negative feedback dampens output, stabilizing the system around an equilibrium point.	 12 Leveraging Interdependence

PRINCIPLE	DESCRIPTION	RELATION
8 **Hick's Law**	The time it takes to make a decision increases as the number of alternatives increase. Hick's Law states that the time required to make a decision is a function of the number of available options. It can be used to estimate how long it will take for people to make a decision when presented with multiple choices and has implications for the design of any system or process. Keep Hick's Law in mind when designing systems that involve decisions based on a set of options to increase efficiency, resulting in less waste.	 2 Waste = Food
9 **Hierarchy of Needs**	In order for a design to be successful, it must meet people's basic needs before it can attempt to satisfy higher-level needs. This principle specifies that a design must serve the low-level needs (it must function) before the higher-level needs (creativity) can be addressed. Good design follows the hierarchy of needs principle, whereas poor designs may attempt to meet needs from the various levels without building on the lower level of hierarchy first which results in a waste of resources. There are five key levels of needs: functionality, reliability, usability, proficiency, and creativity. Functionality needs have to do with meeting the most basic design requirements. Reliability needs have to do with establishing stable and consistent performance. Usability needs have to do with how easy and forgiving a design is to use. Proficiency needs have to do with empowering people to do better things than they could previously. Creativity is the level in the hierarchy where all needs have been satisfied and people begin interacting with the design in innovative ways.	 1 Self-Assembly from the Ground Up

Thinking The following design principles pertain to how we process information when visually communicating a message

PRINCIPLE	DESCRIPTION	RELATION
10 **Life Cycle**	All products progress sequentially through four stages of existence: introduction, growth, maturity and decline. This roughly corresponds with the natural life cycle of birth, adolescence, adulthood and death. For example, a new tablet is envisioned and developed; its popularity grows; after a while its sales plateau; and then finally, the sales decline. Understanding the implications of each of these stages allows designers to prepare for the unique and evolving requirements of a product over its lifetime. The introduction stage is the official birth of the product. The growth stage is the most challenging stage where most products fail. The maturity stage is the peak of the product life cycle. Finally, the decline stage is the end of the life cycle. Always consider the life cycle of a product when planning and preparing for the future. Always work closely with early adopters to refine and tune products in the introduction phase. During the growth phase, focus on scaling product supply and performance. Also focus on customer satisfaction through performance enhancements and improved support during the maturity phase. Then, once you hit the decline phase, focus on facilitating the transition to next generation products.	 3 Evolve Solutions, Don't Plan Them
11 **Depth of Processing**	A phenomenon of memory in which information that is analyzed deeply is better recalled than information that is analyzed superficially. Thinking hard about information improves the likelihood that the information will be recalled at a later time. This phenomenon of memory results from the two ways in which information is processed known as maintenance rehearsal and elaborative rehearsal. Maintenance rehearsal simply repeats the same kind of analysis that has already been carried out. For instance, someone repeats a phone number aloud back to the themselves to help them remember; no additional analysis is performed on the phone number. Elaborative rehearsal involved a deeper, more meaningful analysis of the information. For instance, when someone reads a passage from a book aloud and then has to answer questions about the meaning of it; additional analysis as to word and sentence meaning require additional thought. Consider depth of processing in design contexts where recall and retention of information is important. Use unique presentation and appropriate tools to engage people to deeply process the information relevant to an audience.	 6 Self-Appropriate Technologies
12 **Five Hat Racks**	There are five ways to organize information: category, time, location, alphabet, and continuum. The organization of information is one of the most powerful factors influencing the way people think about and interact with a design. The five hat racks principle asserts that there are a limited number of organizational strategies, regardless of the specific application, so optimization of each category in the simplest manner is key in users understanding and processing information.	 8 Optimize Rather than Maximize

PRINCIPLE	DESCRIPTION	RELATION
13 **Mental Model**	People understand and interact with systems and environments based on mental representations developed from experience. They do this by comparing the outcomes of their mental models with real-world systems and natural environments. With regards to design, there are two basic types of mental models: mental models of how systems work (system models) and mental models of how people interact with systems (interaction models). Design with people's differing interaction models in mind. If there is a standard mental model for how something works, try to design leveraging that model.	 5 Respect Diversity
14 **Ockham's Razor**	Given a choice between functionally equivalent designs, the simplest design should be selected. Ockham's razor asserts that simplicity is preferred to complexity in design. Many variations of the principle exist, Aristotle explaining it as "Nature operates in the shortest way possible." Implicit is the idea that unnecessary elements decrease a design's efficiency and increase the probability of unanticipated consequences. Use Ockham's razor to evaluate and select among multiple, functionally equivalent designs.	 14 Don't Foul your Nest

Synthesis

Below is an informational chart to help demonstrate the combination of the 14 Universal Design Principles & Elements + 14 Design Principles of Nature, which help to form the Indirect Method of the biomimetic design process, theory and system.

Universal Design Principles	Design Principles of Nature
Form Follows Function	Be Resourceful
Mimicry	Adapt to Changing Conditions
Self-Similarity	Organize Fractally
Symmetry	Use Life-Friendly Chemistry
Uniform Connectedness	The System > the Sum of its Parts
Convergence	Foster Cooperative Relationships
Feedback Loop	Leveraging Interdependence
Hick's Law	Waste = Food
Hierarchy of Needs	Self-Assembly from the Ground Up
Life Cycle	Evolve Solutions, Don't Plan Them
Depth of Processing	Self-Appropriate Technologies
Five Hat Racks	Optimize Rather than Maximize
Mental Model	Respect Diversity
Ockham's Razor	Don't Foul your Nest

PROCESS

Integrating the Disciplines, Direct Method

Process, by definition, is a series of actions or steps taken in order to achieve a particular end; a natural or involuntary series of changes; or a systematic series of mechanized or chemical operations that are performed in order to produce or manufacture something.[1] To bring biomimicry into graphic design, it is necessary to go through a series of stages within the process to assist as a planning and organizational tool. Designers need to understand that the process is not simply looking at an organism and mimicking its shape, patterns or color palette. One has to look at the entire system in which the organism lives, the function of the organism, as well as the form and parts of the organism that allows it to survive. It is a process where a designer defines a challenge functionally, seeks out an organism or ecosystem that is the master of that function, and then begins a conversation about how the design might emulate that function or concept,[2] allowing for many different solutions. If designers wish to adopt the biomimetic + graphic design process, then they must also see their profession as an integrated process and a problem-solving discipline. Successful graphic designers correctly define the context of their design, users and constraints. It is cross-disciplinary, allowing architects to learn from animal architecture, and graphic designers to learn from animal communication, biologists and life's principles.[3] The process of collecting several organism examples helps to analyze the principles involved— if many different organisms use variations of a common strategy, then you know your approach is pretty promising. The entire process is a mix of intuitive and deliberate actions, resulting in brainstorming without censorship to create the final solution.

[1] New Oxford American Dictionary 3rd ed © 2010

[2] Jessica Jones, excerpt in *Sustainable Graphic Design*, Wendy Jedlicka

[3] Jessica Jones, excerpt in *Sustainable Graphic Design*, Wendy Jedlicka

This graphic design + biomimetic process is born from new ideas, conceived from old ideals. It is taking nature's time-tested ideals over a period of approximately 3.8 billion years and introducing and integrating them with modern design practices. It is a synthesis of graphic design + biomimicry. The direct method, unlike that of the indirect method using abstracted principles of how nature designs, is exactly what it states: directly going out into the environment and seeking a natural system and organism; finding an example and defining the problem in its context, then finding the organisms with a similar problem and context to see what they do. The goal is to find many divergent organisms to see which has the best and most relevant strategy.[4] Within this process, it is vital designers take into account their time and resource constraints, in order to optimize rather than maximize materials, so they can then appropriately assemble and implement the materials efficiently within their design solutions. This is the core of the biomimetic discipline.

The direct method is what you usually hear about— where the designer or engineer can point to an organism and say 'it's like that.' The value of this method is that even the most creative people still get stuck thinking along certain lines. In fact, a method called TRIZ*, which has been developed to catalog and analyze problem-solving techniques, claims there are just 40 methods that people have ever used to think up new inventions. Since evolution works differently from our brains, nature has used many more. Julian Vincent, author of *Structural Biomaterials*, at University of Bath has been working on extending TRIZ to biology, cataloging and analyzing the ways other organisms have 'invented' new solutions to problems. But so far the best way to find ideas in nature is to go look for yourself; arguably it always will be.

[4] Jeremy Faludi, Biomimicry for Green Design Worldchanging: Change Your Thinking

*TRIZ is the (Russian) acronym for the "Theory of Inventive Problem Solving." G.S. Altshuller and his colleagues in the former USSR developed the method between 1946 and 1985. TRIZ is an international science of creativity that relies on the study of the patterns of problems and solutions; not on the spontaneous and intuitive creativity of individuals or groups.

Defining the problem well is always a challenge in design, but then finding organisms that have relevant strategies is a trick in and of itself. Some examples are easy to find just by going for a walk and paying attention; other examples are more obscure, and require research— online, in books and academic journals, or even by hiring a biologist to consult (a BaDT). It is especially useful to find many examples from wildly divergent sources. For instance, when looking for structures, do not just look at animal bones, but also insect exoskeletons, the branches of trees, or the stems of grasses so that you have design alternatives. Just because a certain strategy evolved in one place does not mean it is the best solution; the power of biomimicry is that one can find many different solutions that he/she may never thought of. It is always a good thing to remember that good biomimetic design is inspiration from nature, not a slavish imitation of it.

As Michael Pawlyn, architect and advocate of biomimicry, states "If you look beyond the nice shapes in nature and understand the principles behind them, you can find some adaptations that can lead to new innovative solutions that are radically more resource efficient. It is the direction we need to take in the coming decades."[4] In essence, within the graphic design + biomimicry process, what is trying to be stressed is that the natural world is a cauldron of research and development, trial and error, where technologies that fail are called fossils and technologies that succeed survive to fight another day. Why reinvent the wheel, when nature has figured out how to slither, walk, hover and fly in so many different ways? Who can deny that nature got here first?

[4] For more information on Michael Pawlyn, see his book, Biomimicry in Architecture. You can also visit TED, www.ted.com, to see him give various TED talks on Biomimicry and its virtues.

When looking at the visual process of biomimetic design, it can be shown in three different models: linear, circular, and branching. It is necessary to show the process in different forms to stress that it overlaps other frameworks and disciplines. The process of integrating the two differing methodologies is bringing nature's wisdom not just to the physical design, but also to the manufacturing process, the packaging, the shipping, distribution, and take-back decisions. We use the three different models to emphasize the reiterative nature of the process to make clear that it evolves in more pattern than one— after solving one challenge, then evaluating how well it meets life's principles, another challenge often arises, and the design process begins anew.

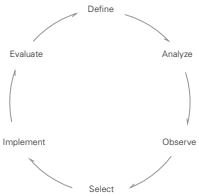
[1] Note, within each of these stages, there are small sub-stages like research, ideation and usability testing that also occur.

There are **6 Stages** within this new process:[1]

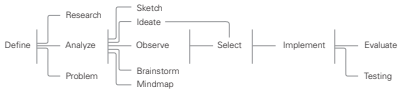
1 Define
2 Analyze
3 Observe
4 Select
5 Implement
6 Evaluate

Linear Model
showing the linear and evolutionary process of nature and design

Circular Model
showing the reiterative nature of the process and continuation of the system within the feedback loop

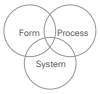


Branching Model
showing the branching nature of the process, visually connecting the smaller sub-areas with the six stages of the process



3 Lenses

There are also three different lenses through which you can evaluate and explore this biomimetic design process through: form, process and system. Carl Hastrich, a professor at OCAD University in Toronto and toy designer, describes looking at biomimicry as placing a heavy emphasis on the system as context, and broader inspiration into why an adaptation from an organism occurs. "Ecosystems are an emergent property of biological organisms and the environment, and in order to really understand it we need to look at the full context. The weakness of some investigations at a systems level occur when there is no deeper understanding of the biological mechanisms that occur for systemic relationships to form. Therefore it is inherently complex to research and a difficult story to tell."[6]

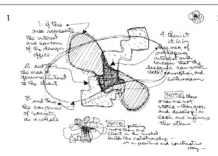


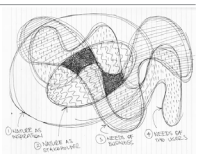
[6] For more inspirational ideas and topics from Carl Hastrich, visit his blog, Bouncing Ideas at http://bouncingideas.wordpress.com/

Below are other organic interpretation models showing design's role and value within society, as well as the reverse, exploring society's value to design. Carl Hastrich took Charles Eames 1968 diagram, explaining the design process as achieving a point where the needs and interests of the client, the designer, and society as a whole overlap, and re-designed it to fit his own mode of thinking regarding biomimicry and design.

[1] Charles Eames, 1969, for the exhibition "What is Design" at the Musée des Arts décoratifs, Paris, France

[2] Humble Evolution of Charles Eames definition of Design; Carl Hatrich's attempt to define "Biomimicry Design" http://bouncingideas.wordpress.com/





SYSTEM SOLUTION

Ethos, Reconnect

To fully understand this graphic design + biomimicry process, it is important to show an example of the process and a final design system solution. The example shown here falls in the Graphic Design category of branding and identity.

1 Define

To create **an identity mark that clearly represents the biomimetic design process**. It must incorporate both natural and organic forms, as well as geometric and mathematical undertones. There must also be a functional quality present within the identity and implied in some fashion.

2 Analyze

What would nature **do**? How would nature **begin**? How would nature **solve this particular problem** and in what **context**? What **tools** would nature use? How would nature **delegate**? How would nature **assess**?

Answers:
Nature would strive to find one form at increasingly smaller scales, optimizing the amount of resources and materials. It would begin with looking at nature's 14 design principles and seek out an organism or system that best describes this problem in order to emulate it. After finding this organism, it would look for materials and tools that were found locally within the system. It would then assess it's design by looking at how it fits in with the rest of the ecosystem.

3 Observe

Go out into the environment and **look at natural systems and organisms**. Which ones best fit within the context of this problem, can be implemented in the simplest way, and can be found locally?

Inspiration
Sand Dollar & Snowflakes

4 Select

Choose the **best form within the organism or system to emulate**. It also needs to imply the overall function of the system and meaning behind the mark.

Inspiration
Golden Ratio & Spiral Growth Patterns of Pine cones and Sunflowers

Modified pentagon pattern found within sand dollars and snowflakes. Represents the geometrical and mathematical half of the identity mark.

Curve taken from the golden ratio proportion and spiral growth pattern of pine cones and sunflowers. Represents the natural and organic half.

5 Implement

Use the **same** pentagon **form throughout**, multiply it at different scales to **preserve resources, time and materials**. Apply it to the natural grid pattern, ensuring both the geometrical/mathematical and organic/natural sides are met.

6 Evaluate

How would **nature assess this design?** Does it use **Nature's 14 design principles?**

Answers:
It shows the methodologies of both graphic design (geometric/mathematical) and biomimicry (natural/organic), represented through continuation of the pentagon form along the golden ratio, curved grid pattern. It optimizes the amount of resources and materials by using the same pentagonal shape throughout at differing scales and using only 1 color at differing hues and tones. It also represents and shows the function of the biomimetic process in representing the evolving stages of the biomimetic process, as well as the continuous pattern of the life cycle of design found within nature.

Final Design System Solution

3 CAVEATS | Where Nature's Principles Will *Not* Help

Although this entire reference guidebook's premise relies on the biomimetic design process and design principles of nature, it is important to be realistic about where these life principles and strategies *will* and *won't* help you. This is not to completely destroy the defense of this thesis or the principles just mentioned, but there are definitely some drawbacks to the way life designs, which you probably do not wish to emulate. However, these drawbacks are necessary in order for there to be progress within the evolutionary process.[1]

[1] These stumbling blocks are based off the work of Steven Vogel, *Cats' Paws and Catapults* and Jeremy Faludi, World Changing: Change Your Thinking.

1 Evolution can only find local optima, not global optima. Put in another way, evolution requires every generation to have an immediate advantage— when transitioning from one strategy or principle to another, you cannot get worse for a few generations, knowing that in the end you will get better than you could have with the original strategy. Thus nature shuts out many design possibilities that we humans can find.

2 Second, natural products need continual maintenance and/or rebuilding. This can easily be turned into an advantage for products meant to biodegrade or planned to obsolesce. Most often it is simply a reminder to not imitate *too* slavishly.

3 Finally, organisms cannot borrow designs from others, they have to evolve from what they have now. Human designers, however, can mix and match freely from different products in whole other genres. There is nothing wrong with making a building whose walls insulate like penguin feathers but are structured like a crab shell. Some companies are doing things like this in biology with genetic engineering, but the law of unintended consequences has frequently shown it to be a bad idea.

CASE STUDIES

You have analyzed the methodologies of both biomimicry + graphic design, and now know the stages of the biomimetic design process. The following case studies demonstrate how the process was applied to actual design scenarios.

LOGO CONCEPTS: IDEO

http://designmomentum.wordpress.com/

IDEO has a very novel and intriguing logo.[1] It is simple and that makes it easy for them to reshuffle information within the design and yet still retain the function of the logo— to recognize and associate with the brand. They are able to evolve to survive and adapt to changing conditions by integrating the unexpected and replicating strategies that work. For example, when colors become dated their designers can easily change the color because the distinct shapes will still provide the functional need. The logo can also easily adapt to fit the piece's shape (square, zig zag, or elongated).

Nature's Principles of organizing fractally and optimizing rather than maximizing has the highest potential to create more sustainable designs.

I'm not sure if the IDEO logo design is inherently life-friendly but I'm sure this concept could be applied elsewhere. If IDEO were striving to help their clients create more life-friendly products, then the logo indirectly would help give IDEO an advantage over the competition who may not be striving to incorporate sustainability into their policies. Graphic designers can choose which companies to create a positive image for.

[1] For more on IDEO, visit http://www.ideo.com/

QR CODES

http://designmomentum.wordpress.com/

Nature uses many senses to communicate. It uses chemistry, and more specifically scent, as one avenue for sending signals to receiving antennae. Each chemical is a certain shape and when received, fits together just perfectly with the receiver's chemical shape. However, humans of course have come to depend mostly on our eyes as our main sense. So it's only natural that the coding system we develop is a visual one. It is interesting though that this code does not talk to our visual antennae directly but rather indirectly through our smart phones.

If nature needed to send a signal made up of simple, common, building blocks and by using low energy processes and reshuffling information, would it create this QR code to use as a signaling device? I think it's on the right track. But I think the QR code definitely has a lot of room to evolve and adapt as well.

Can the coding incorporate other Life's Principles somehow? Can it be more visually appealing, use less space, and contain more information? Should we even be focused on developing a visual code? Or will our smart phones be able to someday pick up senses that we cannot? How can we stop viewing it as just another means of advertising and use it more functionally and efficiently? How could these codes help us be more sustainable in graphic design?

ECO PRINTERS

http://designmomentum.wordpress.com/

Nothing in nature is permanent—everything is in a state of dynamic non-equilibrium. Nature adapts constantly to fit its context for use or it faces extinction. It seems that humans are not as in touch with earth's operating conditions anymore. We create things only how we 'perceive' they should be created and not based on pressing needs or contexts. We are not forced to find other more context specific ways of creating because we already have a plethora of inventions that could work and we have access to inexpensive energy.

Papermaking fibers can typically be recycled only five-to-seven times before they become too short to be recycled again. The *Eco Printer,* designed by Sharsha Lee for Liteon Technology Corp, is a new mutated breed of printer well-adapted to a certain context and was designed to extend the life of paper.

It can remove ink in order to reprint on the same sheet many times over. Increasing the lifespan of paper is the main aim of the Eco Printer. This device uses special ink composed of photographic materials that can be made to disappear after UV irradiation. It contains a UV irradiation device in the paper input tray. Printed paper is irradiated with UV light before it is re-printed. This process takes the ink out of the paper, making it clean and ready to be printed on again. The Eco Printer can be used to print temporary documents and significantly reduce paper wastage.[1]

[1] For more information on the Eco Printer, visit red dot at http://www.red-dot.sg/

The Pencil Printer, designed by Hoyoung Lee, uses Eco Printer concepts and actually prints as well as erases. It feeds on scrap pencil and eraser pieces. It extracts the 'ink' from the pencil graphite and erasing material from the rubber in the eraser pieces. This radical new printer not only prints through one of its ends but has a special exit for erasing the same printed paper too. Environmental conservation at its best![2]

[2] Find other innovative printer ideas here: http://www.ecofriend.com/

ECOFONT

http://designmomentum.wordpress.com/

If nature was in the business of designing typefaces, it would probably look similar to this EcoFont.[1] Except that nature might reverse how it built its letters with ink. Instead of cutting out dots from the line it might create the line with dots. This refers back to the 1st Design Principle of Nature, 'Self-Assembly from the Ground Up,' and the leaf cut out of paper analogy told by Jessica Jones (Benyus).

[1] Download a demo version at http://www.ecofont.com/

Test results for Ecofont Arial 12pts show ink and toner savings of 28%. In using this as opposed to traditional typefaces, you are being resourceful and material and energy efficient.

Arial

Ecofont Arial

RIT TAGA 2011

http://taga.rit.edu/2011/

The RIT Taga 2011 researched and investigated the effects that font choice, typographic design, and page layout have on the conservation of ink and paper.[1] This is one part of a broader concern with the environmental sustainability of digital printing. Measurement of ink and paper consumed in the printing of documents must take into account not only choices of fonts but also their spacing and arrangement within the defined parameters and pragmatic goals of specified documents. The typefaces and layouts common in academic printing were not designed with.

[1] To download a .pdf the full abstract and thesis report on RIT Taga 2011, go to http://taga.rit.edu/2011/

The goal of reducing ink and paper consumption, but moderate changes in typographic format and can result in substantial savings in ink and paper. It was concluded that compared to thesis composition in Arial, the use of Times New Roman or a modified Déjà vu Sans font can result in savings of ink from 19-25%. Compared to typical RIT thesis guidelines, thesis formats designed for economy can result in paper savings of 27-48%. When dealing with students whose average page consumption numbers in the thousands, such as the graduate students at RIT, a reduction of even 27% (around 270 pages out of 1000) can be a huge savings.

Table 5. Ink saved compared to Arial

Typeface	Pixels	Ink Savings
Arial Regular	1,071,130	-
Déjà vu Sans Book	1,164,699	-
Déjà vu Sans Light	894,124	16.53%
Déjà vu Light Thesis	863,994	19.34%

INTERFACEFLOR CARPET

http://designmomentum.wordpress.com/

Interface is the world's largest designer and maker of carpet tile. Their slogan and mantra being 'By definition, we are the world's largest designer and maker of carpet tile. For us, Design is a mindset and Sustainability is the journey of a lifetime. We are Design with Purpose.' Their environmental goal is to go for zero; that is zero emissions, zero waste, and zero oil.[1] It is a tough challenge since carpet is made from oil but by using less energy and material, making products that last and recycling old carpet into new, they already have most off oil carpet.

The Interface mission and goal for their future carpet design directly correlates with three out of the 14 Design Principles of Nature:

7 Be Resourceful
8 Optimize Rather than Maximize
9 Use Life-Friendly Chemistry

[1] For more on Interface Carpet visit http://www.interfaceflor.com/

In this specific case study, InterfaceFLOR looked to the forest floor for inspiration. After walking through the forest during a design charette, their designers had an epiphany— they noticed that the artifacts on the forest floor made a very random pattern yet was still nice on the eye. They mimicked the non-homogeneous, yet cohesive pattern in carpet tiles so that off-spec batches could still be used. Or, if a stain appears on one tile, it can be replaced from a tile from a different die lot yet still look pleasing amongst the other sun faded and slightly different colored tiles. Customers had 70% less installation waste and didn't have to back-stock identical replacement tiles (which most ends up unused). By 2009, the company's accumulated avoided costs from its waste elimination activities equaled $433 million.

WINEHIVE

http://www.kickstarter.com/projects/

Made in America from recycled aluminum, the WineHive is an eco-friendly honeycomb wine rack, with infinite add-on capability. It was designed by John Paulick in Philadelphia, PA.[1] The WineHive is made with just a single part, that repeats itself to form an infinite array of honeycomb structures. It can be customized to fit anyone's growing wine bottle collection. The WineHive pack consists of 12 parts. It can form a 5 bottle wine rack or combine with other packs to form larger configurations. The more packs you have, the more configurations you can make.

Paulick recently graduated from Biomimicry 3.8's Biomimicry Specialist Certification Program said that he was inspired by fractal honeycomb patterns found in nature.

[1] John Paulick started a Kickstarter campaign with the goal of raising $15,000 in 30 days to finance the initial production and packaging of his bio-inspired honeycomb wine rack. The elegantly designed and aptly named WineHive attracted attention from 681 backers who provided over $65,000 in funding, more than 400% of his goal.

999 BOTTLES

http://www.artefactgroup.com/

The 999 Bottle is not just another water bottle.[1] It is a beautifully designed system that helps you track and visualize the positive impact you can have on the environment by drinking from re-usable bottles instead of disposable ones. The stainless steel bottle features a clever three numbered dial along its length to help you track of how many times you re-use it. Each time you refill, simply advance the dial one notch. The numbers steadily add up!

An accompanying iPhone app tells you what the numbers mean, giving context to your conservation through insightful visuals that graphically depict and share the impact of your efforts. The app also allows you to join forces with your friends and track your combined impact. Most people understand and agree that disposable water bottles are expensive, a very inefficient use of resources and harmful to the environment. But that understanding does not necessarily translate into action. According to CNBC, Americans buy 51 billion bottles of water a year, and recycle less than one quarter of them. The remaining bottles end up in a landfill or as litter jeopardizing wild life and creating unforeseen consequences to human health and the environment.[2]

The 999 bottle is a great example of Nature's Principle of using feedback loops. Nature constantly receives direct environmental feedback and changes its behaviors and reactions accordingly. For humans, it is hard to see that we are fouling our own nests because it is out of sight and out of mind. But with this newly designed water bottle, our waste it is no longer out of mind. Graphic designers, and designers alike, have the opportunity to give humans the visual cues they need to act differently.

[1] Designed by Ferrid van Engelen at Artefact in Seattle, WA. To support the project and the increased use of feedback loops, you can buy the water bottle here: http://www.artefactgroup.com/#/content/support-999bottles-on-kickstarter

[2] http://www.kickstarter.com/projects/999bottles/999bottles

Mimicry is perhaps the oldest and most efficient method for achieving major advances in design.

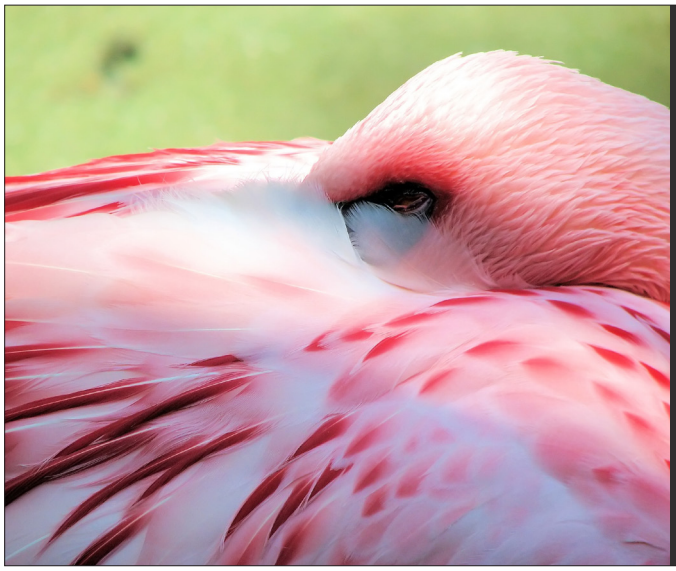
WILLIAM LIDWELL

DEFINING
ANALYZING
3 **OBSERVING**
SELECTING
IMPLEMENTING
EVALUATING

How Would Nature Solve the Problem?

The third stage in the biomimetic design process after analyzing the problem is *observing*. During this stage, designers will discover the natural models and systems that exist within nature. In order to emulate the system or organism that best fits their design problem, it is crucial designers abstract the strategies and functions looking to life as a model for inspiration. In asking how nature would solve this design problem, designers must look to the environment where visual communication predominates to discover biological strategies that can translate into innovative ideas.[1] Through this observing stage, designers will find novel ideas that have been refined over millions of years.

[1] Jessica Jones, excerpt in *Sustainable Graphic Design*, Wendy Jedlicka



PATTERNS & SURFACE MIMICRY

Animal Camouflage

Natural patterns are fundamental to us getting along in the world. By appreciating natural patterns, we better understand the basic patterns we intuitively recognize, thus we better know how to communicate.[1] Both graphic design and nature rely on these intuitive pattern systems to transfer visual messages and stimuli, knowing the end user will perceive what these specific patterns signify, thus communicating the message successfully. Design, in the broadest sense, is the ability to communicate through an intuitive sense of pattern. It is the difference between lucid communication and meaningless noise.[2] It is the basics of conscious awareness of patterns that brings cohesion to a sometimes chaotic landscape by allowing us to see contrast as well as similarity. It is fundamental that designers recognize these patterns during the observation stage of the biomimetic design process in order to better adapt with nature, since it is not just people that have these instinctive and intuitive pattern recognition sensibilities. It is necessary to take a closer look at how organisms live, function and communicate. In doing this, designers will come to realize that creatures have the same intuitive intelligence as humans do that allows them to recognize certain symbols. For instance, bees find honey down a diverging maze by navigating colonized directional patterns after a few attempts. Chimpanzees use symbols not only to identify objects but also to describe conceptual impressions of the world around them. In studying chimpanzees, it was noticed that they even use rudimentary language to communicate and say 'yes' and 'no' in response to someone talking to them over the phone.[3]

Pattern awareness cues designers to make and select the most appropriate relationships that specifically describe a client's unique attributes, while embedding universal design concepts and principles. Thus resulting in elegant, clear, recognizable design understood by all cultures.

[1] Maggie McNab, *Decoding Design*

[2] Maggie McNab, *Decoding Design*

[3] Maggie McNab, Decoding Design

In talking about basic communication patterns and techniques, nature uses mimicry as its form and technique when it comes to particular pattern making and design. Mimicry is the act of copying properties of familiar objects, organisms, or environments in order to realize specific benefits afforded by those properties. In nature, mimicry refers to the copying of certain properties to hide from or deter other organisms.[4] This is where animal camouflage, or surface mimicry, plays a significant role in evolution and survival of the fittest.

However, camouflage is not strictly about chameleons changing the color of their skin in an instant; it is also about polar bears being white and not brown like grizzlies. In order to understand animals with this ability of mastering the art of deception, it is important to know why animals have this cunning ability. A major concern of animals is to protect themselves from predators in order to survive, reproduce and pass off their genes to a future generation. Many animals have evolved adaptations known as 'anti-predator devices' and use camouflage to blend in with their natural environments and patterns in an attempt to be unrecognizable by predators. However, there are exceptions: animals which are dangerous to eat (i.e. wasps) advertise with warning coloration.

Animal camouflage can relate to design in the sense that mimicry refers to copying properties of familiar objects, organisms or environments in order to improve the usability, likability, or functionality of an object. Design and nature create with three forms of mimicry in mind: surface, behavioral, and functional. Surface mimicry (camouflage) is making a design *look* like something else; Behavioral mimicry is defined as making a design *act* like something else; Functional mimicry is defined as making a design *work* like something else.

[4] William Lidwell, Kritina Holden and Jill Butler, *Universal Principles of Design*

FRACTALS & THE SIERPINSKI TRIANGLE

Natural Algorithms

Fractal, by definition, means a curve or geometric figure, each part of which has the same statistical character as the whole. Fractals are useful in modeling structures (such as eroded coastlines or snowflakes) in which similar patterns recur at progressively smaller scales, and in describing partly random or chaotic phenomena such as crystal growth, fluid turbulence, and galaxy formation.[1] Fractals have a number of characteristic properties, and some of the best known examples of fractals possess the intriguing feature of self-similarity which is usually the result of a basic, natural algorithm process called *recursion*. Recursion occurs when a system receives input, modifies it slightly, and then feeds the output back into the systems as input. Fractals exhibiting self-similarity and recursion show the same structure on all scales.[2] The term 'fractal' was first used by mathematician Benoît Mandelbrot in 1975. Mandelbrot based it on the Latin frāctus meaning 'broken' or 'fractured,' and used it to extend the concept of theoretical fractional dimensions to geometric patterns in nature.[3]

However, before Mandelbrot coined the term 'fractal,' there was an earlier Polish mathematician by the name of Waclaw Sierpinski who was studying fractal patterns, just in a different manner and by a different name. In 1915, Sierpinski published the first set of pictures of what is now known as the Sierpinski triangle.[4] The Sierpinski triangle is composed of three smaller triangles, each of which is just a copy of the original Sierpinski triangle.

[1] New Oxford American Dictionary 3rd ed © 2010

[2] William Lidwell, Kritina Holden and Jill Butler, *Universal Principles of Design*

[3] Benoît Mandelbrot, *The Fractal Geometry of Nature*

[4] Michael Field and Martin Golubitsky, *Symmetry in Chaos: A Search for Pattern in Mathematics, Art and Nature*

[4] Michael Field and Martin Golubitsky, *Symmetry in Chaos: A Search for Pattern in Mathematics, Art and Nature*

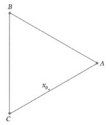
[5] By definition, a process or set of rules to be followed in calculations or other problem-solving operations, New Oxford American Dictionary 3rd ed © 2010

[7] For more detailed instructions, see Michael Field and Martin Golubitsky, *Symmetry in Chaos: A Search for Pattern in Mathematics, Art and Nature*

What Sierpinski was trying to illustrate was that this process may be repeated *ad infinitu;* each of the smaller triangles consists of three scaled down copies of itself. If you look closely, you will see that any one of the smaller triangles in the Sierpinski triangle is the original triangle.[5] One of the remarkable features of fractals, like the Sierpinski triangle, is that they can often be produced using very simple instructions or algorithms.[6] The novelty of these instructions is that they are based on choosing a sequence of random numbers.

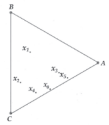
A random iteration algorithm for obtaining arbitrarily close approximations to the Sierpinski triangle is as follows:[7]

1 Begin by choosing an equilateral triangle in a plane
2 Label the vertices A, B, C and pick a point inside the triangle (outside will work as well– the end result is just the same)
3 Now randomly choose one of A, B, or C. If say B is chosen, move the point halfway to vertex B and mark the point. Similarly, if A is chosen, move the point halfway to A, and the same for C.
4 Now, repeat the process to obtain a sequence of points that can be plotted



Put simply:

1 Begin by choosing an equilateral triangle in a plane
2 Shrink the triangle to ½ height and ½ width, make three copies, and position the three shrunken triangles so that each triangle touches the two other triangles at a corner
3 Repeat step 2 with each of the smaller triangles



The actual fractal is what would be obtained after an infinite number of iterations.

The algorithm for constructing the Sierpinski triangle was based on fixing an equilateral triangle or, more precisely, fixing the vertices of that triangle. It is natural to modify the algorithm a little by replacing the triangle with a square or indeed by any one of the regular polygons.[8] For instance, suppose we had initially chosen a regular pentagon in the plane. After choosing an initial point inside of it, you could have defined the algorithm by making random choices of vertices and at each stage of the iteration, move halfway towards the vertex. Thus creating the algorithm and fractal pattern, which are both found naturally recurring throughout nature.

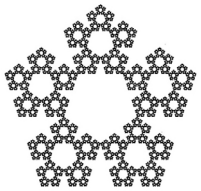
[8] Michael Field and Martin Golubitsky, *Symmetry in Chaos: A Search for Pattern in Mathematics, Art and Nature*

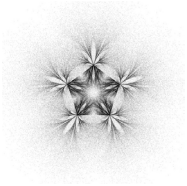
The purpose of showing fractal patterning and the Sierpinski triangle is to demonstrate that patterns and design systems within nature do not occur unmethodically over time, but due to the naturally occurring algorithms. The ubiquity of self-similarity in nature hints at this underlying order and algorithm, and suggests ways to enhance the aesthetic composition of human-created forms and perhaps their structural composition as well.

Relating this back to the earlier discussion of the surface mimicry of animals, if one was to take a close look at the hide, skin, or texturing patterns of animals, one would find that it is a structured, well thought-out pattern based upon a logical grid system and fractally organized algorithms. One of the best known and most beautiful system of patterning seen in nature is the hexagonal conformations most notoriously connected with the honey bee's cell. The hexagonal symmetry in plants and animals "doth neatly declare how nature Geometrizeth and observeth order in all things."[9]

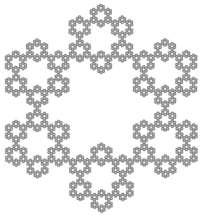
[9] D'Arcy Wentworth Thompson, *On Growth and Form*

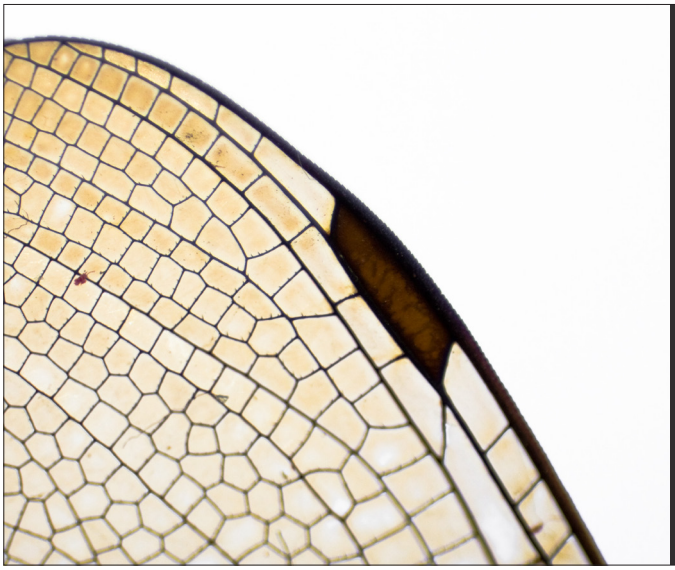
Sierpinski Pentagon





Sierpinski Hexagon





GRAPHICAL SOLUTIONS

Tessellation Patterns

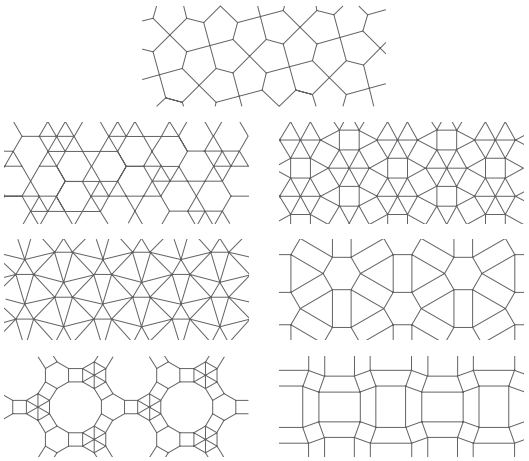
The word tessellation means to fit or join polygons into flat, continuous patterns. A tessellation pattern is created by joining three or more sides of a set of polygons. The point where the sides meet is called a vertex; the sum of the angles around a vertex equal 360°.[1] Regular tessellations are created by combining regular, congruent polygons in a uniform manner. The only three regular, congruent polygons that can possibly be used in regular tessellations are the triangle, the square and the hexagon, sometimes pentagon because only they have interior angles that divide evenly into 360°.[2] A semi-regular tessellation is uniform and consists of more than one type of regular polygon. There are uniform/nonuniform and periodic/non-periodic tessellations. In a uniform tessellation all vertices are congruent and the organization of polygons around each vertex is the same. In a periodic tessellation a group of regular polygons can be moved to a new position within the tessellation, where it will fit together exactly with a similar group of regular polygons.[3] The hexagonal honey bee cell is one of the best known tessellation patterns and the interest here is looking into how using these joined or fit polygons can create a continuous, unique pattern design, similar to mosaic tiling, and how they can relate to the surface mimicry of animals and fractals. All share similar methodologies and principles: the use of symmetry, the Sierpinski triangle, and the concept of implementing natural algorithms and self-similarity that occur within nature. It is organizing fractally, while also optimizing the amount of materials needed to create these patterns.

[1] Charles Wallschlaeger & Cynthia Busic-Snyder, *Basic Visual Concepts and Principles for Artists, Architects and Designers*

[2] Charles Wallschlaeger & Cynthia Busic-Snyder, *Basic Visual Concepts and Principles for Artists, Architects and Designers*

[3] Charles Wallschlaeger & Cynthia Busic-Snyder, *Basic Visual Concepts and Principles for Artists, Architects and Designers*

Tessellation Grid Patterns To the right are 7 tessellation patterns designed and inspired by surface mimicry, animal camouflage, fractal patterning, the Sierpinski triangle and natural algorithms.

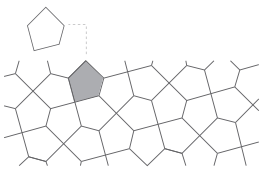


Graphical Solutions, Pattern Design

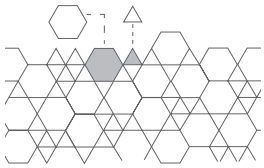
To make these pattern designs, the biomimetic design process was used. The first stage began with defining the problem: What would Nature do? How would nature create these specific patterns and in what context?[1] How would it utilize form within function? After asking these questions and going through the appropriate stages of defining, analyzing, and observing, the selection of which animals to emulate was the next step. The animal skins and camouflaging/surface mimicry techniques that were chosen were the *giraffe, leopard, chameleon, iguana, tortoise, monarch butterfly, and cephalopod (Blue-ringed Octopus)*. After the animals were chosen, the implementation stage of the process could now begin, which is where images of the same hue and mimicry patterns were chosen to be repeatedly placed beneath each polygon. The images seen looking through each polygon act as a window, showing various color hues, changes and patterns similar to those seen on the animal's transformed-camouflaged skin. In evaluating the designs, it is apparent that by using the tessellation and fractal techniques, taking either a singular polygon or multiple, different polygons and repeating them throughout at differing scales, was successful in creating individual grid-like patterns. The functioning aspect is in the form of deception to emulate the animal and disguise the form by creating shapes for specific pattern purposes. By incorporating the biomimetic + graphic design process, it is evident that these patterns are derived from nature through the use of polygon forms and images of nature, while also showing subtle hints of the geometric and mathematical side of design in creating grid systems. What is shown for each graphical solution is the final pattern design, the underlying mathematical and geometric grid system, as well as the natural inspiration and surface mimicry of the specific animal.

[1] A good example of how nature would go about doing this is seen in the hexagonal honey bee cell.

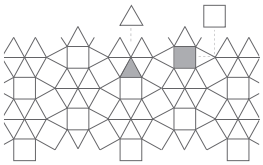
Regular Tessellation Pattern using the same pentagonal shape throughout | Giraffe

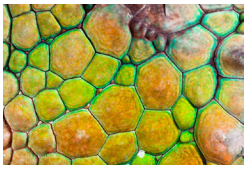


Semi-Regular Non-Uniform Periodic Pattern using 2 polygonal shapes: hexagon and triangle | Leopard

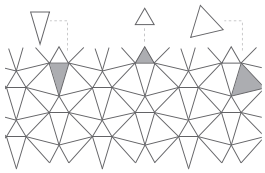


Semi-Regular Non-Uniform Non-Periodic Pattern using 2 polygonal shapes: triangle and square | Chameleon

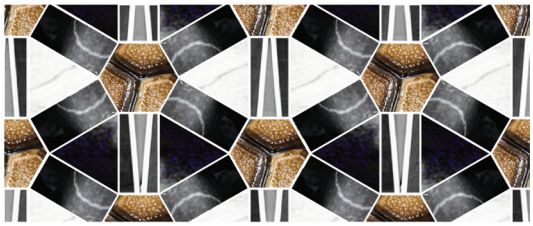


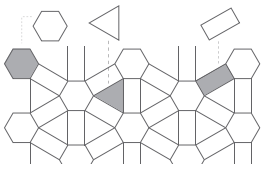


Regular Uniform Non-Periodic Pattern using the same triangular shape throughout at differing sizes | Iguana

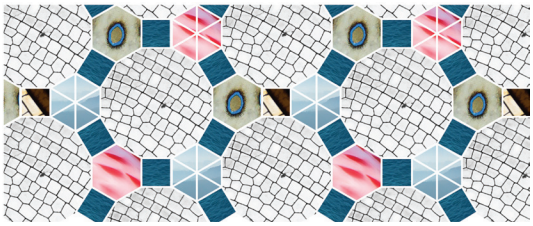


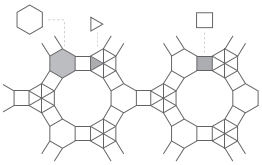
Semi-Regular Non-Uniform Non-Periodic Pattern using 3 polygonal shapes: hexagon, triangle and rectangle | Tortoise



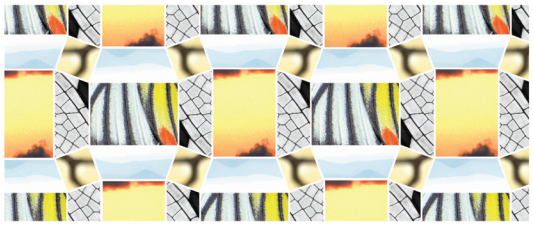


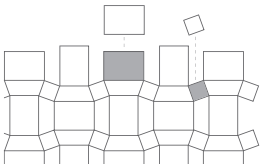
Semi-Regular Non-Uniform Periodic Pattern using 3 polygonal shapes: hexagon, triangle and square | Cephalopod





Regular Uniform Non-Periodic Pattern using the same rectangular/square shape throughout | Monarch Butterfly





CASE STUDIES

After learning the principles and techniques of surface mimicry, fractals and tessellation patterns, it is easier to understand when applied to an actual design scenario. The following packaging design case study clearly demonstrates the third stage of the biomimetic design process, *observing*.

VISUAL MIMICRY

http://designmomentum.wordpress.com/

Just as some flies mimic wasps to better ward off predators, off-brands can mimic well-known brands to appeal to a pre-targeted market.[1] Many of these generic store brands have become pretty successful at mimicking the appearance and packaging of the dominant, flourishing, and popular name brand. The designers of the store brand use the time saved coming up with and testing the initial brand strategy for researching other biomimetic strategies.[2] While designers still have to spend some time learning and imitating, they can stay current on trends when conditions change and can imitate the best designs, altering them ever so slightly.

To learn from past designs, designers can look through design magazines, blogs, and other materials that relate to their specialty. Just as organisms adapt to what works to keep them alive through the process of evolution, graphic designers, through trial and error, learn significantly from past mistakes and successes. Keep abreast of current design context shows how others are responding, or not responding, to these changes.

Another scenario is in looking at 'fake' spots on wildlife and the camouflaging tactics many use. Just as these attributes can misdirect or even attract prey by startling them into believing they are something resembling their predator, graphic design pieces can alert users to view specific elements of a design target first.[3] Many direct mailers do this using bold typography or images clearly visible yet putting fine print at the bottom telling the whole truth. Users will easily learn the trick and a new design must be attempted. If the goal is sustained communication, endeavor to form designs that help foster cooperative relationships, not ones that fool the user.

This case study perfectly exemplifies some of Nature's Design principles:

3 Evolve Solutions, Don't Plan Them
4 Adapt to Changing Conditions
13 Foster Cooperative Relationships

This means foregoing authorship and accommodating to the times by creating design solutions that will be sustainable and better the end user and target audience.

Generic Store Brand

Name Brand

[1] Jessica Jones, Design/Momentum Blog

[2] Jessica Jones, *Sustainable Graphic Design*, Wendy Jedlicka

[3] Jessica Jones, *Sustainable Graphic Design*, Wendy Jedlicka

Creativity can solve almost any problem.
The creative act, the defeat of habit by
originality, overcomes everything.

GEORGE LOIS

DEFINING
ANALYZING
OBSERVING
4 **SELECTING**
IMPLEMENTING
EVALUATING

What Tools Would Nature Use?

The fourth stage in the biomimetic design process after observing is *selecting*. In context, this is all about the selection of tools and materials necessary to produce the final design solution. It is asking the questions, what tools would nature use? How would nature start the selection process? It is first necessary to look back at why our current consumption cycles began and how we can prevent the drought of the finite resources available. Since the Industrial Revolution began in the 1800s, the world has been on an unprecedented consumption binge. Since 1950 alone, the world's people have consumed more goods and services than the combined total of all humans who ever walked the planet.[1] Nature would never let this happen and cannot afford to.

[1] Dave Tilford, *Sustainable Consumption: Why Consumption Matters*

LIFE-FRIENDLY MATERIALS

Reducing our Carbon Footprint

Modern design emerged in response to the Industrial Revolution, when reform-minded artists and artisans tried to impart a critical sensibility to the making of objects and media. Design took shape as a critique of industry, yet it gained its mature and legitimate status by becoming an agent of machine production and mass consumption.[1] In the 1940s and 1950s, organic forms and materials provided designers with a humanist vocabulary that affirmed society's place within the natural world. By the end of the century, a new 'organicism' had emerged, as nature itself was transformed by a host of technologies.[2] Although the Industrial Revolution gave rise to modern capitalism today and it greatly expanded the possibilities for the material development of humankind, it does so at a severe price. The electronic offshoots of the Machine Age threaten to dissolve some of nature's most valuable assets. Since the mid-eighteenth century, more of nature has been destroyed than in all prior history. While industrial systems have reached pinnacles of success, able to muster and accumulate human-made capital on vast levels, natural capital, on which civilization depends to create economic prosperity, is rapidly declining, and the rate of loss is increasing proportionate to gains in material well being.[3]

Every consumer product comes from the Earth and returns to it in one form or another. We have increased our supply of material goods and services at the direct expense of natural services.[4] As Janine Benyus says, 'heat, beat, treat' has become the de-facto slogan of our industrial age; it is the way we synthesize just about everything.[5] Nature, on the other hand, cannot afford to follow this strategy. As previously mentioned of Benyus in the second chapter, *Analyzing*, under the ninth design principle of nature, 'Use Life-friendly Chemistry,' life cannot put its factory on the edge of town; it has to live where it works.

As a result, nature's first trick of the trade is that nature manufactures its materials under life-friendly conditions— in water, at room temperature, without harsh chemicals or high pressures.[6] Despite what we would call 'limits,' nature manages to craft materials of a complexity and a functionality that humans can only envy. Nature has the innate capability to customize materials through the use of templates. In contrast, humans muddle by in using industrial chemistry with final products that are a mishmash of polymer-chain sizes, with most too long or too short to be of ideal use. Nature makes only what she wants where she wants and when she wants.[7] There is no waste on the cutting-room floor. As designers, we are one step ahead in the right direction, using templates and grid systems in our designs to effectively and efficiently use the resources available to us. However, society as a whole tends to maximize when it perceives there is an inexpensive abundance of materials readily available to it. Yet the Earth has limits and boundaries, and there is a finite amount of resources at our disposal. It is important to see the entire system and become aware of costs to others when designing or choosing supplies.[8] In terms of choosing supplies, in theory it has been known that picking an eco-material is a better move than picking an un-eco one. However, if a designer does not know why a material is eco, how to implement it correctly, or even if it actually is 'eco,' taking a typically shallow replacement approach can end up with impacts far worse than the things being replaced.[9] This is where possessing the knowledge and skills of how to effectively select the right tools and materials is crucial. Relying on the sixth design principle of nature, 'Self-Appropriate Technologies,' will help to do so. As graphic designers, even though we cannot directly change how paper is manufactured, we can voice our concerns, suggest alternatives, and hope that people upstream and downstream catch hold of and implement our ideas. Today, we assume that the way we are doing it is the best way, but it might not be.

[1] Ellen Lupton and J. Abbott Miller, *Design Writing Research: Writing on Graphic Design*

[2] Ellen Lupton, *Skin*

[3] Paul Hawken, Amory & Hunter Lovins, *Natural Capitalism*

[4] Dave Tilford, *Sustainable Consumption: Why Consumption Matters*

[5] Janine Benyus, *Biomimicry: Innovation Inspired by Nature*

[6] Janine Benyus, *Biomimicry: Innovation Inspired by Nature*

[7] Janine Benyus, *Biomimicry: Innovation Inspired by Nature*

[8] Wendy Jedlicka, *Sustainable Graphic Design*

[9] Wendy Jedlicka, *Sustainable Graphic Design*

The fatal flaw of technologic and human thinking, especially in the years since the Industrial Revolution and WWII is that modern technology is like a two-legged stool: "Our science was well founded in physics and chemistry, but flawed by a missing third leg— the biology of the environment."[10] It is crucial that society and modern industries today recognize and understand our routine of over consumption and how it is detrimental for future generations. David Tilford in his article, "Sustainable Consumption: Why Consumption Matters" explains in the simplest way how we are over-consuming goods and services and negatively impacting natural ecosystems:

> Our cars, houses, hamburgers, televisions, sneakers, newspapers and thousands upon thousands of other consumer items come to us via chains of production that stretch around the globe. Along the length of this chain we pull raw materials from the Earth in numbers that are too big to even conceptualize. Tremendous volumes of natural resources are displaced and ecosystems disrupted in the uncounted extraction processes that fuel modern human existence. Constructing highways or buildings, mining for gold, drilling for oil, harvesting crops and forest products all involve reshaping natural landscapes. Some of our activities involve minor changes to the landscape. Sometimes entire mountains are moved.[11]

Recognizing that we need to reduce our ecological and carbon footprint is the initial step towards a more sustainable future. An ecological or carbon footprint is defined as the amount of productive land area required to sustain one human being.[12] As most of our planet's surface is either under water, there are only 1.9 hectares (about four football fields) of productive area to support each person today (grow food, supply materials, clean our waste). That might sound like a lot but our collective ecological footprint is already 2.3 hectares. This means that, given the needs of today's human population, we already need 1.5 Earths to live sustainably. But this assumes all resources are divided equally. Those with the largest carbon footprint— the biggest consumers of global resources— are US citizens, who require 9.57 hectares *each* to meet their demands.[13] If everyone in the world consumed at that rate, *5 Earths* would be needed to sustain the population. People in Bangladesh, in contrast, need just 0.5 hectares; for people in China today, the footprint is 1.36 hectares.[14] Part of why the US carbon footprint is so large has to do with trade access to more than the country's balance of natural capital. Much of this natural capital comes from countries that have some resources but not much else from which to earn cash.[15] Due to corruption, or desperation, many of those countries are selling off their resources quickly, regardless of the long-term consequences. After six months, 99% of the resources to make things we use is converted to waste— disposed of as finished goods, but mostly as processed waste.[16]

The main point to understand about the selection of tools and materials within the biomimetic design process is that whatever is naturally here is all we have. Whatever humans make does not go 'away.' We need to eliminate the concept of waste which means to design things— products, packaging and systems— from the very beginning on the understanding that waste does not exist.[17] Nature has relied on this mindset and because of that, has flourished on this planet for billions of years. Yet, this may not be the case in the near future if we continue our bad habits. Ways to shift these bad habits towards good ones would be to constantly ask yourself these fundamental questions: Does it make us or the planet sick? (Don't do it!) Are you picking your material because it is the best one for your application or the same as it is always done before/your competitor is using it? Can we be happy without having more and more stuff?

[10] David Wann, *Biologic: Designing with Nature to Protect the Environment*

[11] Dave Tilford, *Sustainable Consumption: Why Consumption Matters*

[12] Wendy Jedlicka, *Sustainable Graphic Design*

[13] Wendy Jedlicka, *Sustainable Graphic Design*

[14] Statistical data from www.footprintnetwork.org

[15] Wendy Jedlicka, *Sustainable Graphic Design*

[16] Annie Leonard, The Story of Stuff, Free Range Studios video at www.storyofstuff.com

[17] William McDonough & Michael Braungart, *Cradle to Cradle*

Get certified! *www.c2ccertified.com* Cradle to Cradle certification provides companies with the means to tangibly and credibly measure achievement in environmentally-intelligent design and design for material reutilization such as recycling

CASE STUDIES

The following biomimetic design case studies clearly demonstrate how in self-appropriating technologies and selecting efficient materials and resources, one can still achieve quality designs that are sustainable, as well as conducive to life.

CELERY DIVIDER TABS

http://designmomentum.wordpress.com/

Celery Design Collaborative seeks out beautiful and innovative ways to make things. The more interesting the challenge for them is to use design as a means of effecting change.[1] So, they took on the design challenge to try and come up with a simple solution to eliminate the waste created when a divider tab is cut out of a larger sheet of paper. And they did it. In the end, Celery designed a simple die-cut pattern where the tab can be folded out of the middle of the paper and placed through a slot to hold the tab in place.[2]

This consequently influences where a graphic designer places their designs and what message it communicates. This is a very good example of how nature would design using the principles of graphic design. These divider tabs also illustrate how graphic designers can have impact on an entire system. First, the designers had to recognize a status quo— they do not have to work with pre-made divider tabs that create waste when manufactured. And then they need to take that thought and design challenge to come up with a successful solution.

[1] Celery Design Collaborative, www.celerydesign.com

[2] Jessica Jones, DesignMomentum blog

CERTIFICATE CASING

http://designmomentum.wordpress.com/

Instead of buying a plastic diploma or certificate case off of the internet, Biomimicry 3.8 designed their own. This is the first prototype with even more potential to make it more life-friendly in the next iteration. As all designers know, there are time and resource constraints in which a project must be completed, so most projects will not be completely life-friendly the first go around. Biomimicry is inevitably iterative just as nature is constantly adapting and evolving.

This adopts the following design principles of nature:

6 Self Appropriate Technologies
7 Be Resourceful
8 Optimize Rather than Maximize
13 Foster Cooperative Relationships

The case doubles as a clip board and a mat for framing, and of course a protective casing for getting it back home.

Biomimicry 3.8 did not want the end users to just stick it in their bookshelf (where most plastic diploma cases end up) but instead showcased on a wall. The graduates are part of a larger network and meme and by providing a pre-made mat this encourages them to frame it and remember this bigger idea. The clipboard also suggests continued learning and collaboration toward a greater goal.

The laser cuts were also made on a personal laser cutting machine. Local connections are a leverage point for designers in cultivating cooperative relationships.

Perhaps in the end, it will not be a change in technology that will bring us to the biomimetic future, but a change of heart, a humbling that allows us to be attentive to nature's lessons.

JANINE BENYUS

[1] Wendy Jedlicka, *Sustainable Graphic Design*

DEFINING
ANALYZING
OBSERVING
SELECTING
5 **IMPLEMENTING**
EVALUATING

How Would Nature Delegate?

The fifth stage in the biomimetic design process after selecting the appropriate tools and materials is *implementing*. It is here where the collaboration at the design table begins. BaDT's, architects, designers, business men, CEO's all come together. Using the language of change, businesses are now asking what natural capital is and how it is spent. What economic lessons can be drawn from nature? How do market forces shape the way we live, work, and play? How can we nurture the corporate green thumb? Today's leaders understand the interplay between governments and people, stockholders and stakeholders, humans and the environment and how all things interconnect and direct how and what we need to create.[1]

BIOMIMICRY + CORPORATIONS

Network & Facilitate

Bringing biomimicry into every corporation around the world is a dream for biomimetic designers. In doing that, it would enable for more interdisciplinary team work where biologists would work with architects, designers, and CEO's, ultimately cultivating and fostering cooperative relationships around the globe. Today, business attitudes are already acting on this and implementing the biomimetic design process within their corporations. The reason biomimicry is so important to integrate into businesses and corporations and why this topic is stressed is because of the power and ability these corporations have and hold in changing the perception of their consumers; which in turn has the power to generate change and the perception of society in general. In an interview with Janine Benyus, she explains why biomimicry now is so vital and why it is the key to bettering our future:

> We humans are at a turning point in our evolution. Though we began as a small population in a very large world, we have expanded in number and territory until we are now bursting at the seams. There are too many of us, and our habits are unsustainable. Having reached the limits of nature's tolerance, we are finally shopping for answers to the question: "How can we live on this home planet without destroying it?" Just as we are beginning to recognize all there is to learn from the natural world, our models are starting to blink out— not just a few scattered organisms, but entire ecosystems. A new survey by the National Biological Service found that one-half of all native ecosystems in the United States are degraded to the point of endangerment. That makes biomimicry more than just a new way of viewing and valuing nature. It's also a race to the rescue.[1]

So, in order to act on this biomimetic design process in hopes for betting the future, what is need is a shift in perception, including a shift in the way we live and work within businesses. Many innovators are starting to grasp this concept.

[1] For the full interview with Janine Benyus, go to http://www.biomimicryguild.com/janineinterview.html

One of them is, Michael Pawlyn, a world renowned architect, established the architecture firm *Exploration* in 2007 to focus on environmentally sustainable projects that take their inspiration from nature and biomimicry.[2] He recently published a book, *Biomimicry in Architecture,* that not only gives examples of where biomimicry has been used in corporations, but also answers some of the issues that naysayers raise.[3] Pawlyn argues that a lot of the technology needed to make this integration of biomimicry within corporations happen is already available. In the book, he points to George Chan's sorghum brewery in Tsumeb, Namibia, which was built to deliver 'good beer, no pollution, more sales and more jobs.' It produced 12 products instead of simply just beer and these included the nutrient-rich alga spirulina, mushrooms grown in the spent grains and gas from an anaerobic digester which was used instead of burning wood.[4] Pawlyn enthuses:

> For me, biomimicry is just one of the best sources of innovation to get to a world of zero waste because those are the rules under which biological life has had to exist. And it hasn't just existed in a really miserable, self-denying way, but in a celebrated, abundant and regenerative way. I think we need to move to a far more positive way of talking about the future. A lot of sustainable design has got very stuck in very familiar solutions and even familiar materials and forms, and so there's so much more to it. If you look beyond the nice shapes in nature and understand the principles behind them, you can find some adaptations that can lead to new innovative solutions that are radically more resource efficient. It's the direction we need to take in the coming decades.[5]

[2] For more information about Michael Pawlyn and his work with *Exploration*, go to http://www.exploration-architecture.com

[3] Katie Scott, Biomimicry in Architecture and the Start of the Ecological Age, 2/22/12 http://www.wired.co.uk/

[4] Katie Scott, Biomimicry in Architecture and the Start of the Ecological Age

[5] Katie Scott, Biomimicry in Architecture and the Start of the Ecological Age

CREATIVE SESSIONS

Cross-Disciplinary Design Tables

One of the largest, contributing factors when integrating biomimicry into corporations is the use of cross-disciplinary design tables during creative brainstorming sessions. This is where innovators and professionals from all fields come together and sit down to discuss the potential biomimicry has in helping their businesses and corporations thrive in the marketplace and co-exist with the surrounding ecosystems. Two major design companies, IDEO and Smart Design, put biomimicry and BaDT's (Biologists at the Design Table) to the test, tackling design problems for real-world clients alongside biologists from the Biomimicry Institute.[1] The magazine, *Fast Company,* posted the following case studies and wanted to do a follow up/check in with both IDEO and Smart Design to see if they thought biomimicry as a new tool could help advance their businesses. Below is a section of the article from fastcompany.com, shown to best illustrate what the companies thought of the entire process:

[1] See the Case Studies section at the end of this chapter for further information on these companies and their biomimetic process and approach towards design problems

Richard Graves, vice president of the community for the U.S. Green Building Council, said he was skeptical at first having IDEO take a biomimetic approach to redesign their organizational structure and if it would prove useful beyond just theory. "To be honest, I was not sure how much we would get that would be usable, but I see many ideas that can be explored and developed," he says. "I was surprised at how many of the ideas seem very practical and implementable." One particular solution that stood out to him was an idea to signal the health of USGBC chapters that was inspired by a pink flamingo: The "health" of the flamingo—or how much shrimp it eats— is outwardly reflected in the shade of pink of its feathers. "Having a simple, clear characteristic that reflects the health of an organization would be very useful in the chaotic world we live in," he says. "How to achieve this?"

[2] For the full article, go to http://www.fastcodesign.com/1661865/could-biomimicry-build-a-better-company-than-your-boss

[3] For more information about applying for the Biomimicry Professional Certification Program, go to http://www.biomimicry.net/ProfessionalPathways/upcoming_courses/bspacialty.html

Ultimately, Graves was impressed with the way biomimicry reframed their internal issues. "Biomimicry is a great tool to integrate into the design process of an innovative company or organization," he says. "We saw it as a way to have a different lens on challenges we have been working on for some time."

The second challenge focused on Smart Design's ideas for cities to conserve water as part of IBM's SmarterCity initiative. "IBM itself is no stranger to a biomimetic approach," says Ian Abbott-Donnelly of IBM Big Green Innovations, pointing to a recent computer-chip using the same self-assembling nanotechnology that builds snowflakes and seashells. But the fact that Smart Design was able to examine biomimicry at city-scale, using larger principles based on an ecosystem's feedback loops, proved that biomimicry can work for their initiative working at the civic level. "This work gives some well thought-out stories of how to apply biomimicry to cities which can easily be discussed with teams operating in cities," he says. "I am hoping that this new thinking will enable cities to explore and implement solutions which have the right insight to be effective." [2]

The Biomimicry Guild is currently working on a concept called the Biomimicry Innovation Process, which can help take the process from this charrette point into conception and marketplace in the most sustainable way. Bringing business and biomimicry closer together will be due to the variety of participants in the Biomimicry Professional Certification program, an intensive biomimicry training program.[3] The latest round of graduates in the two-year program included biologists, engineers, designers and even four people with business backgrounds and it is that kind of diversity and cross-disciplinary approach that will ensure that biomimicry can be embraced by various walks of life.

CASE STUDIES

Below are the two case studies with IDEO & the USGBC, as well as Smart Design's IBM SmarterCity Initiative, that were previously mentioned. Both show how by incorporating the biomimetic design process within your own corporation's creative sessions can lead to new, innovative ideas and design solutions.

IDEO & THE USGBC

http://www.fastcompany.com/

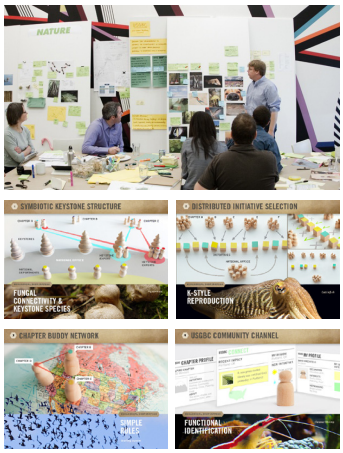
The United States Green Building Council (USGBC), most notably founded the LEED certification system that rates structures by sustainability.[1] With 80 local chapters nationwide, they struggle with challenges like making group decisions and the ability to keep members motivated and involved. The USGBC wanted to investigate redesigning their organization in a way that was more closely aligned with their mission to protect and celebrate nature. In their words, they wanted to be more 'resilient and organic' in how their organization communicates with stakeholders.

IDEO's Boston office took on this hefty problem from the USGBC, which would essentially require a system-wide redesign for the way that their members communicate. Yet after interviewing USGBC stakeholders, IDEO's team reframed the statement to broaden the focus to the organization's structure itself and how different parties would connect within it, including the tools that would help make these connections. The reframed challenge became to 'design an organization strategy to improve the effectiveness of a locally distributed effort, while staying aligned to the national USGBC mission.' A biomimetic approach was particularly intriguing to the IDEO team because the firm is so well known for their human-centered design process. But instead of dismissing their own approach for a strict biomimicry approach, the IDEO team and their assigned biologist at the design table (BaDT) Tim McGee had a better idea. Working with IDEO's project lead, designer Eleanor Morgan, McGee weaved biomimicry into IDEO's human-centered approach, resulting in a 'mash-up' that incorporated biomimicry thinking into IDEO's existing design pathways.

The result was almost paradoxical, says creative director Jane Fulton Suri. "We were really happy just to go along with their process and throw ours out the window," she says. "But in talking with Tim it was clear we'd all benefit from learning about how these two processes could effectively meld together."

McGee thinks the hybrid approach revealed some insight into the Biomimicry Guild's process. "I think IDEO's outstanding insights into 'human centered' design can actually help define and drive what it means to do biomimicry," he says, "because at the center of our relationship with nature is ourselves." For IDEO, the challenge gave the team a new set of tools they hope to apply to future projects. "It really does feel like an amazing untapped resource," agreed Fulton Suri. They also realized how biomimicry in general could be a part of their own mission to create positive impact, says Morgan. "If we could distribute these BaDTs around the world we could be in a better place."

[1] Seen here is just a portion of the article on fastcompany.com. To see the full article, go to http://www.fastcompany.com/1643489/biomimicry-challenge-ideo-uses-nature-to-reorganize-the-usgbc



SMART DESIGN & IBM'S SMARTERCITY INITIATIVE

http://www.fastcompany.com/

IBM's SmarterCity initiative is a program that uses the company's information technology to help municipal governments create healthier, more intelligent urban environments for their residents.[1] Using their ability to collect and analyze data, IBM is able to provide information about elements of daily city life ranging from weather and traffic to water usage and air quality. But what they have done with that data has largely been used to make policy and economic decisions. IBM asked how they could use nature to understand how these overlays of information could help guide residents toward making better personal decisions for the good of the city. A New York-based team at Smart Design accepted their challenge.

After having a discussion with IBM, and walking through some day-in-the-life exercises that explored issues facing urban dwellers, Smart Design chose to focus on water conservation. Because of the complexity surrounding its systems, water is often misunderstood, says Tucker Fort, Smart's director of industrial design. "But unlike something like energy, it's a finite resource." Water was also something that residents interacted with everyday, and since IBM's goal was to make cities more responsive and resilient, using a biomimetic approach for encouraging more responsible water usage could have a real impact when implemented across an entire municipal area. Smart zeroed in on urban water consumption to explore how nature could inspire relevant, everyday solutions for city inhabitants to conserve water.

To immerse themselves in a biomimetic mindset, Fort, along with director of interaction design Ted Booth, and their team were introduced to the emerging discipline of biomimicry by their BaDT (biologist at the design table) Mark Dorfman. After a biomimicry primer, the team engaged in a blind-folded exercise where they were encouraged to smell, taste, touch, and listen to nature— anything that would break them of their reliance on vision. This is something Dorfman calls "quieting our cleverness." "If I were to show you a pine cone, you would see it and immediately know what it is, and that might be the end of your curiosity and exploration," says Dorfman. "But if you're blind-folded and handed a pine cone, you'll have to explore its shape, texture, smell, before figuring out what it is."

The hope is that this process will open the designer's mind to viewing living things through a functional lens— a way that is particularly relevant to solving design challenges. Examining this representation of nature's complex systems, the designers realized that their solution would not come directly from an organism, but from this entire system as a whole: These core principles for life could work as a metaphor for a city, inspiring and informing solutions to make a healthier and smarter environment. For this solution, it also helped them to realize a simple truth: That some of the world's largest challenges will be overcome by changing the behavior of each individual within a larger system. "The modern city is just like an ecosystem," says Fort. "It seems so obvious, but if you just go right below the surface, there are all these inspirations and connections that are so meaningful."

[1] Seen here is just a portion of the article on fastcompany.com. To see the full article, go to http://www.fastcompany.com/1648801/biomimicry-challenge-smart-design-ecosystem-approach-to-water-conservation-for-ibm

We must be the change we
wish to see in the world.

MAHATMA GANDHI

DEFINING
ANALYZING
OBSERVING
SELECTING
IMPLEMENTING
6 **EVALUATING**

How Would Nature Assess?
The last stage in the biomimetic design process after implementing the solution is *evaluating*. This is the point where a designer should step back and really assess the final design solution, asking incremental questions such as: Are the 14 design principles of nature evident and appropriately used? Did I understand and implement the solution to its fullest potential? In asking these questions, it is therefore, very important that designers understand and realize how we, humans, process information visually. There is a psychology and depth of processing involved within the change of the biomimetic mindset; changes in which we evaluate nature, how we design and ultimately, how we live our day-to-day.

THE BIOMIMETIC MINDSET

Psychology of Processing

It is crucial designers know how individuals process information. In order for an individual to understand a design solution resulting from the biomimetic design process, he/she needs to know the 'biomimetic' thinking behind the designer. Otherwise, one may think that any biomimetic design is 'just a form mimicking a natural form;' which is superficial thinking. There needs to be an evaluation of the final design solution, as well as an evaluation of how humans consume, teach, live, spend, work, play, and design. Are people doing all of these things in the manner that is the most conducive to life here on this planet? How would nature assess society's daily habits? In applying the biomimetic mindset, it opens up the possibility to make the necessary changes to live more sustainably.

In order to change one's mindset, perception, and/or outlook, one needs to expand the possibilities and one's creativity. This is the beauty of integrating biomimicry and nature's design principles within graphic design; coming up with ideas or solutions that one may have never stumbled upon otherwise. In order to expand one's creativity, he/she needs to affirm one's own individual creativity. Although many facets of human creativity are similar, they are never identical. All pine trees are very much alike, yet none is exactly the same as the other.[1] This is the benefit of having BaDT, combining creative minds of all types and backgrounds to create a unique design solution.

Along with expanding possibilities and creativity, focus is also key. All too often we are bombarded with information; an information tidal wave of sorts. With minds processing techniques and abilities, we do not make the fullest use of our ability to see.

[1] Michael Michalko, *Thinkertoys*

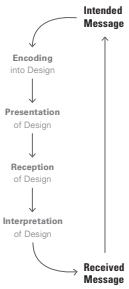
[2] Michael Michalko, *Thinkertoys*

[3] Done in the defining stage of the Biomimicry + Graphic Design process

[4] Michael Michalko, *Thinkertoys*

[5] See information chart on right

We move through life looking at a tremendous quantity of information, objects, and scenes, and yet we *look* but do not *see*.[2] However, before one starts looking for ideas, he/she needs to know what one is looking for and what his/her goal is.[3] The important step to take next is to set the problem or design challenge down in writing. Since our attention is constantly shifting, one may become indecisive about what, if anything, he/she should focus on. Psychologists have demonstrated that people are able to keep only about five – nine pieces of information in his/her mind at a time.[4] Therefore, keeping sketches and thoughts written down related to one's project is essential in order to 'bake' them into one's shared consciousness. As designers, we rely heavily on the possibility system. Moving ahead with our ideas and information we gathered to create hypotheses and visions. These give us the framework through which to look at things (nature) and also something to work towards (biomimetic design solution). Therefore, our perception is the most important part of our thinking...how we look at the world, what things we take into account and, ultimately, how we structure our world. Perception works as a self-organizing information system, just as within nature, building on the smaller parts and creating larger sub-systems. Such systems allow the sequence in which information arrives to set up patterns; these patterns being the environments in which we encounter and organize to create recognizable systems for processing information. There is a life-cycle with which we process.[5] As designers, it is pivotal we know this to understand how our viewer is perceiving our design solutions. The more we accept responsibility and dedicate ourselves to generating ideas found within nature, the higher the probability of reaching an innovative solution. Thinking is the ultimate human resource. The quality of our future will depend entirely on the quality of our thinking and of our mindset.



THE DESIGNERS ACCORD

http://www.designersaccord.org/

Many organizations are beginning to adopt the biomimetic mindset within their creative processes, understanding the implications it has over people's ability to process information in an easier and more efficient manner. One organization, in particular, has strived to do this since it's origin. With a call-to-action, in July of 2007, dubbed the Kyoto Treaty for design, the Designers Accord was founded as a global coalition of designers, educators, and corporate leaders, working together to create positive environmental and social impact.[1] Since then, the Designers Accord has become one of the fastest moving and most influential organizations within the creative community: It has been adopted by over 170,000 members, representing each design discipline.

In 2008, *Fast Company* wrote that it is "on a path to change the culture of the creative community from bottom to top, and with it, the way everything is made."

Creatives from all over the globe are working to integrate the principles of sustainability into all aspects of design: from education, to practice and production, and ultimately consumption. They are catalyzing new thinking by collectively building our intelligence around issues of climate change and social justice, and tackling those challenges with optimism and creativity.

The Designers Accord provides access to a community of peers that share methodologies, resources, and experiences around environmental and social issues in design. This encapsulates the unifying philosophy of the Designers Accord: open source. They advocate inverting the traditional model of competition, and encourage sharing the best practices so everyone can innovate more efficiently, quickly and effectively. This relates to the third design principle of nature: Evolve Solutions, Don't Plan Them. This means design without authorship and letting go with dignity, allowing for open source.

[1] Seen here is just a portion of the article on fastcompany.com. To see the full article, go to http://www.fastcompany.com/blog/valerie-casey/networked-culture/case-studies-sustainability-designers-accord-introduction

This is an example of one of the Designers Accord's Case Studies. Frog design's color changing, lichen-based wall art is used to detect carbon monoxide or other pollutants in the home.

Another Designers Accord Case Study involving IDEO. This is IDEO's hourglass-inspired interface that visually controls electricity usage at home. When the hourglass empties, the electricity that runs through the house turns off automatically.

PROGRESSING

The Future of Biomimetic Design

"At this point in history, as we contemplate the very real possibility of losing a quarter of all species in the next thirty years, biomimicry becomes more than just a new way of looking at nature. It becomes a race and a rescue. Here at the beginning of the twenty first century, environmental reality is setting in, pushing us to find saner and more sustainable ways to live on Earth. Equally important is what is pulling us towards biomimicry— that is, our deepening knowledge of how the natural world works.

Biological knowledge is doubling every five years, growing like a pointillist painting toward a recognizable whole. For the first time in history, we have the instruments— the scopes and satellites— to feel the shiver of a neuron in thought or watch in color as a star is born. When we combine this intensified gaze with the sheer amount of scientific knowledge coming into focus, we suddenly have the capacity to mimic nature like never before."[1]

Janine Benyus

As aspiring designers, we must continue to push the envelope well past just sustainable and green graphic design and think with the biomimetic mindset and attitude, ultimately practicing with greater holistic awareness. There needs to be a basic, mutual understanding by all designers that by putting biological systems and nature's design principles into modern design practices results in ground-breaking, innovative design solutions. This biomimetic design process has the potential, if implemented correctly, to create and revolutionize an entirely new market of technological devices and designs that are unparalleled of those seen today.

[1] Janine Benyus, interview http://www.biomimicryguild.com/janineinterview.html

[2] Steven Vogel, *Cats' Paws & Catapults*

[3] Read more about Janine's thoughts on biomimicry and education at http://www.fastcompany.com/1741948/innovative-nature-baking-biomimicry-in

It is incremental that designers apply what they learn from nature and this biomimicry + graphic design process documenting their expansive, growing portfolios with their intellectual property and findings within their own process. There also must be an eagerness and willingness among designers to continue to collaborate with other innovators of different disciplines. One can only hope that corporations and businesses will demand there be BaDT's present at every cross-disciplinary design table in the near future. Nature teaches us the virtues of flexibility. Leaves, large algae, and feathers show us how to economize on material, how to change shape as environmental forces change, how to enlist the environmental forces themselves to produce those changes.[2] It would be irresponsible of us if we do not choose to listen and learn from nature's time tested ideals since it is there where we will find the answers to the problems we are currently grappling with today.

In regards to biomimicry moving forward within educational institutions for future generations to learn about the power of biomimicry + design, Benyus is most certain that biomimetic design labs are going to start appearing in schools very soon. "The future is that biologists will have a seat at the design table. But it starts with education and then trickles out to the workplace. Looking back, we had human factors, and now that's commonplace in a design conversation. I'm optimistic biomimicry will enjoy the same consideration in the coming years."[3] It is a very exciting time as biomimicry continues to gain mainstream acceptance, with institutions and collaborations blossoming. The design industry and the planet need biomimicry integrated into the design process and it is going to take positive, hopeful, eager and willing designers to act on it. As Benyus says, "the design challenge of our century is we need a way to remind ourselves of those geniuses and to somehow meet them again."

BIBLIOGRAPHY

Ausubel, Kenny. *Nature's Operating Instructions: The True Biotechnologies.* Sierra Club Books, 2004.

Benyus, Janine. *Biomimicry: Innovation Inspired by Nature.* New York: William Morrow and Company, Inc., 1997.

Elam, Kimberly. *Geometry of Design.* New York: Princeton Architectural Press, 2001.

Field, Michael. *Symmetry in Chaos: A Search for Pattern in Mathematics, Art and Nature.* Philadelphia: Society for Industrial and Applied Mathematics, 2009.

Hawken, Paul, Amory and L. Hunter Lovins. *Natural Capitalism.* Boston: Little, Brown and Company, 1999.

Jedlicka, Wendy. *Sustainable Graphic Design.* Hoboken: John Wiley & Sons, Inc. 2010.

Lidwell, William, Kritina Holden, and Julia Butler. *Universal Principles of Design: 100 ways to Enhance Usability, Influence Perception, Increase Appeal, Make Better Design Decisions, and Teach through Design.* Rockport Publishers, Inc., 2003.

Lupton, Ellen and J. Abbott Miller. *Design Writing Research: Writing on Graphic Design.* New York: Kiosk, 1996.

Lupton, Ellen and Jennifer Cole Phillips. *Graphic Design The New Basics.* New York: Princeton Architectural Press, 2008.

Lupton, Ellen. *Skin: Surface Substance + Design.* New York: Princeton Architectural Press, 2002.

Mandelbrot, Benoit. *The Fractal Geometry of Nature.* Boston: W.H. Freeman and Company, 1983

McDonough, William and Michael Braungart. Cradle to Cradle: Remaking the Way We Make Things. New York: North Point Press, 2002.

McNab, Maggie. *Decoding Design: Understanding and Using Symbols in Visual Communication.* Cincinnati: HOW Books, 2008.

Michalko, Michael. *Thinkertoys.* Berkeley: Ten Speed Press, 2006.

Rees, Robin. *The Way Nature Works.* Mitchell Beazley International Ltd., 1992.

Simmons, Christopher. *Just Design.* Cincinnati: HOW Books, 2011.

Taylor, Benjamin De Brie. *Design Lessons from Nature.* New York: Watson-Guptill Publications, 1974.

Thompson, D'Arcy Wentworth. *On Growth and Form.* Great Britain: Cambridge University Press, 1961.

Tilford, Dave. *Sustainable Consumption: Why Consumption Matters.* Sierra Club, 2000.

Vincent, Julian. *Structural Biomaterials.* New York: Princeton University Press, 1990.

Vogel, Steven. *Cats Paws and Catapults: Mechanical World of Nature and People.* W. W. Norton & Company, 1998.

Wallschlaeger, Charles, and Cynthia Busic-Snyder. *Basic Visual Concepts and Principles for Artists, Architects and Designers.* Boston: McGraw Hill, 1992.

Wann, David. *Biologic: Designing with Nature to Protect the Environment.* Boulder: Johnson Printing Company, 1994.

Wann, David. *Deep Design: Pathways to a Liveable Future.* Washington, DC: Island Press, 1996.

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82 http://www.sxc.hu/
85 Elam, Kimberly. *Geometry of Design.* pg 9
88-91 http://designmomentum.wordpress.com/
92 http://taga.rit.edu/2011/
93 http://designmomentum.wordpress.com/
98, 102 http://www.sxc.hu/
104 http://www.stc-phoenix.com/
105 Field, Michael. Symmetry in Chaos. pg 143
107 http://koozdra.wordpress.com/
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12 http://www.biomimicryinstitute.org/
18 Jessica Jones, Design Momentum Blog http://designmomentum.wordpress.com
21 Janine Benyus,Biomimicry in Action July 2009TED Talks, www.ted.com
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33-34, 40, 41 Jessica Jones, Design Momentum Blog http://designmomentum.wordpress.com
50-58, 77 Jeremy Faludi, Biomimicry for Green Design, Worldchanging: Change Your Thinking
78 Michael Pawlyn, Biomimicry in Architecture and the start of the Ecological Age, http://www.wired.co.uk/
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DESIGN Margaret McKosky

TYPOGRAPHY Univers LT Std
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Memphis LT Std
Medium

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Linen: ProLine Oatmeal Linen (made of 100% renewable cotton, never bleached, coated or dyed)

GRAPHIC DESIGN + BIOMIMICRY
Final Print Application

School of Design
College of Imaging Arts and Sciences
Rochester Institute of Technology

Appendix 9 Glossary of Terms

BaDT: acronym for 'Biologists at the Design Table'

Biomimicry: the design and production of materials, structures and systems that are modeled after biological entities and processes from the Greek word *bios* (life) and *mimesis* (imitation)

Ecological (Carbon) Footprint: the amount of productive land area required to sustain one human being

Fractal: a curve or geometric figure, each part of which has the same statistical character as the whole

Meme: an element of a culture or system of behavior that may be considered to be passed from one individual to another by non-genetic means, especially imitation

Biomimetic graphic design in itself is a meme. It is a design process and style that has been spread throughout today's culture via various channels and networks of communication. To be active within this biomimetic graphic design unit, designers must transmit their ideas through the form of cultural analogues that can respond to the ever-changing times and conditions.

Process: a series of actions or steps taken in order to achieve a particular end; a natural or involuntary series of changes; a systematic series of mechanized or chemical operations that are performed in order

Recursion: the repeated application of a recursive procedure or definition

Recursion is a natural algorithm process that occurs when a system receives input, modifies it slightly, and then feeds the output back into the systems as input.

Tessellation: to fit or join polygons into flat, continuous patterns

TRIZ: the (Russian) acronym for the 'Theory of Inventive Problem Solving'

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85	Elam, Kimberly. *Geometry of Design.* pg 9
88-91	http://designmomentum.wordpress.com/
92	http://taga.rit.edu/2011/
93	http://designmomentum.wordpress.com/
98, 102	http://www.sxc.hu/
104	http://www.stc-phoenix.com/
105	Field, Michael. Symmetry in Chaos. pg 143
107	http://koozdra.wordpress.com/
108	http://www.sxc.hu/
113, 114	personal photograph
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124	http://www.sxc.hu/
130, 131	http://designmomentum.wordpress.com/
134, 138	http://www.sxc.hu/
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	Alissa Walker, What Would you Ask Nature? http://www.fastcompany.com/
32-34, 40, 41	Jessica Jones, Design Momentum Blog http://designmomentum.wordpress.com
50-58, 77	Jeremy Faludi, Biomimicry for Green Design, Worldchanging: Change Your Thinking
78	Michael Pawlyn, Biomimicry in Architecture and the start of the Ecological Age, http://www.wired.co.uk/
81	Carl Hastrich, http://bouncingideas. wordpress.com/
88-91	Jessica Jones, Design Momentum Blog http://designmomentum.wordpress.com
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93	Jessica Jones, Design Momentum Blog http://designmomentum.wordpress.com
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120	Jessica Jones, Design Momentum Blog http://designmomentum.wordpress.com
129	www.footprintnetwork.org www.storystuff.com
130, 131	Jessica Jones, Design Momentum Blog http://designmomentum.wordpress.com
136, 137	Janine Benyus, http://www.biomimicry guild.com/janineinterview.html
	Michael Pawlyn, http://www.exploration architecture.com
	Katie Scott, Biomimicry in Architecture and the Start of the Ecological Age, http://www.wired.co.uk/
141-144	http://www.fastcompany.com http://www.biomimicry.net/
153	http://www.designersaccord.org/
156, 157	Janine Benyus, http://www.biomimicry guild.com/janineinterview.html
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